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Gestational Weight Gain and Maternal Health Among Hispanic Women

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GESTATIONAL WEIGHT GAIN AND MATERNAL HEALTH AMONG HISPANIC WOMEN

A Dissertation Presented

by

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DEDICATION

To Jackson & Dominic: to the moon and back (around, around the world five times).

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ABSTRACT

GESTATIONAL WEIGHT GAIN AND MATERNAL HEALTH
AMONG HISPANIC WOMEN

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More than 70% of women do not gain within their target range of gestational weight gain (GWG), as recommended by the Institute of Medicine (IOM) in 2009. Risks associated with inadequate GWG include small-for-gestational age, low birthweight, pre-term birth, and difficulty establishing breastfeeding. Risks associated with excessive GWG include large-for-gestational-age, macrosomia, and delivery complications. There are also long-term consequences for maternal and fetal metabolic processes. Higher pre-pregnancy BMI, lower education level, and higher parity are known risk factors for excessive GWG. There are also possible racial / ethnic differences, and Hispanic women, in particular, may be at high risk for excessive GWG. Thus, the research aim was to examine multiple measures of GWG prospectively, including potentially modifiable risk factors for and consequences of GWG outside IOM recommendations among pregnant Hispanic women in Proyecto Buena Salud (PBS), a prospective cohort study.

Chapter 1 examines the association between stress / anxiety in early, mid- and late pregnancy and GWG. Among 1308 Hispanic women, high stress in early pregnancy was associated with lower total GWG; high stress in late pregnancy was associated with lower

rate of GWG; and high anxiety in early pregnancy was associated with both lower rate of GWG and lower total GWG.

Chapter 2 examines the association between GWG and cesarean delivery. Among 1215 Hispanic women, each additional pound of GWG was associated with a 2% greater risk of cesarean delivery. Rate of GWG was also positively associated with the risk of cesarean delivery.

Chapter 3 examines the association between GWG and abnormal glucose tolerance (AGT) / gestational diabetes mellitus (GDM). Among 1277 Hispanic women, GWG was inversely associated AGT, but not significantly associated with GDM. Specifically, excessive GWG until the GDM screen was associated with a 35% lower risk of AGT. This association was only significant among women with normal pre-pregnancy BMI.

In conclusion, stress and anxiety were inversely associated with GWG, and GWG was positively associated with cesarean delivery and inversely associated with AGT (among women with normal pre-pregnancy BMI). These projects contribute to an understanding of the correlates and consequences of GWG at various points throughout pregnancy.

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CHAPTER 1

STRESS AND ANXIETY IN EARLY, MID- AND LATE PREGNANCY AND GESTATIONAL WEIGHT GAIN AMONG HISPANIC WOMEN

Abstract

More than half of pregnant women do not gain within recommended guidelines for weight gain during pregnancy. Inadequate or excessive gestational weight gain (GWG) is associated with poor maternal and infant outcomes. Prior epidemiological literature suggests that stress and anxiety may contribute to GWG but has been limited by the failure to use validated measures of stress and anxiety, by measuring only total GWG as opposed to trimester-specific GWG or rate of GWG, and by including primarily non-Hispanic women. Therefore, we investigated the association between stress and anxiety in early-, mid-, and late pregnancy and GWG (total, rate of GWG, and adherence with IOM recommendations) in Proyecto Buena Salud, a prospective cohort study of 1,583 Hispanic pregnant women aged 16-40 years. Interviewers administered validated measures of stress and anxiety three times over the course of pregnancy. GWG was abstracted from medical records. After adjusting for important risk factors, we found that women in the highest quartile of stress in early pregnancy had lower total GWG (B=-4.00, p=0.031) and a lower rate of GWG (B=-0.131, p=0.037) than women in the lowest quartile. Compared to the lowest quartile, women in the highest quartile of trait anxiety had lower total GWG (B=-4.22, p=0.044) and lower rate of GWG (B=-0.138, p-0.021). Neither stress nor anxiety in early, mid or late pregnancy were associated with adherence to IOM guidelines for total GWG or for rate of GWG. Findings provide information on potentially modifiable risk factors for GWG in this high risk population.

Introduction

Inadequate or excessive GWG according to the Institute of Medicine (IOM) recommended guidelines is associated with poor maternal and infant outcomes (1,2). Gaining less than IOM recommendation (inadequate GWG) has been associated with preterm birth, low birthweight, small-for-gestational-age infants and failure to initiate breastfeeding (1,3–5). GWG exceeding IOM recommendations (excessive GWG) has been associated with high birthweight, macrosomia, large-for-gestational-age infants, and increased risk for cesarean delivery and postpartum maternal weight retention (1,3–5). Excess maternal GWG during pregnancy may further be associated with increased offspring fetal growth and adipose tissue as well as influence hypothalamic control of metabolism and appetite leading to greater offspring BMI in childhood and into adulthood (6,7).

The IOM recommends a target range of GWG and rate of GWG for women, depending on their pre-pregnancy BMI (1). Most women do not gain within IOM recommendations. Depending on the population, as many as 70% of women gain more or less than IOM recommendations based on their pre-pregnancy BMI (2,8). Women who are overweight or obese before pregnancy are more likely to gain excessive weight during pregnancy (9). Close to 52% of Hispanic women in the US are overweight or obese at the start of their pregnancy as compared to 44% of non-Hispanic white women (10–13). Therefore Hispanic women are at increased risk of excessive weight, compared to non-Hispanic women.

Established risk factors for failing to gain within GWG guidelines include pre-pregnancy BMI higher or lower than the normal BMI range, taller height, lower education and higher parity (14). Research on racial and ethnic differences in GWG is

sparse, and it remains unclear if the determents of GWG are similar across racial/ethnic groups (1). Stress and anxiety may influence the amount of weight gained during pregnancy via neuroendocrine disruptions to metabolism and weight control (15–19) and changes in lifestyle and behaviors that impact GWG (18,20,21).

High stress is common during pregnancy, with research indicating that 25% of pregnant women experience psychosocial stress during pregnancy (22). Stress is more prevalent among pregnant Hispanic women (26.9%) (23) as compared to the general US population of pregnant women. Approximately 6.6% of all pregnant women in the US have a diagnosed anxiety disorder (24). Further, research indicates that between 24% and 33% of women present with anxiety (25) or score above generally accepted cut-offs for anxiety (26) during pregnancy. The prevalence of diagnosed anxiety among Hispanic women has not been reported, however recent studies have found that average levels of anxiety during pregnancy are fairly high among Hispanic women (from the Spielberger State-Trait Anxiety Inventory, possible scores ranging from 20-80, $M=41.6 \pm 10.4$, above the suggested cut point of 39–40 for clinically significant anxiety symptoms) (27,28) and anxiety may be greatest during early pregnancy (29).

The majority of epidemiologic studies examining the association between stress and GWG found no association (11,30–36), although several reported conflicting results (14,37). Similarly, few studies have examined the association between anxiety and GWG and the majority found no association (30–32,38). However, these studies had several limitations including failure to use validated scales to assess stress and anxiety in pregnancy, only assessing total GWG, and limiting the study population to predominantly non-Hispanic women.

Therefore, we investigated the association between stress and anxiety in early-, mid-, and late pregnancy and GWG (total, rate of GWG, and adherence with IOM recommendations) using data from Proyecto Buena Salud, a prospective cohort study of 1,610 Hispanic pregnant women.

Physiology

There are two potential mechanisms through which stress and/or anxiety may impact GWG, a neuroendocrine mechanism and a lifestyle behaviors mechanism.

In terms of the neuroendocrine mechanism, pregnancy-related adjustments in basal and resting metabolism occur, in part, in response to increases in progesterone. Progesterone levels rise to increase appetite and assist with GWG, specifically fat stores in early pregnancy (16). Stress and anxiety are both associated with hyper- or hypo-activity of the hypothalamic–pituitary–adrenal (HPA) axis, which results in disturbances to hormonal levels in the body, including cortisol and progesterone (16). Therefore the normal increases in progesterone that occur during pregnancy may be disrupted by experiencing high levels of stress and/or anxiety. This disruption could alter the physiologic response to pregnancy and lead to reduced uptake of glucose by tissue in non-abdominal tissue and a corresponding increase in fat deposits in the abdomen (17), resulting in excessive maternal and fetal tissue gain. Alternatively, this disruption may reduce the efficiency of fat tissue synthesis, making it more challenging for women to gain both maternal and fetal tissue (18). For example, a study by Picone and colleagues suggest that high stress leads to decreased GWG through decreased efficiency in using energy, rather than through reduced energy consumption (37). In addition to disrupting tissue synthesis, the hyper- or hypo-activity of the HPA axis may increase cortisol levels,

which when paired with high progesterone levels, may further increase appetite for calorie dense foods and sweet foods, and lead to excessive energy consumption and therefore GWG (19).

Stress and anxiety may also impact GWG through changes to lifestyle and health behaviors. Prior research indicates that stress and/or anxiety causes changes in food consumption behaviors, for example coping behaviors such as food consumption ("stress eating"), that contribute to either excessive or inadequate energy consumption. A woman's energy consumption during pregnancy will directly impact her ability to meet the amount of weight the IOM recommends they gain during pregnancy and may make it more likely that she'll fall below or exceed the recommended weight range (18,20). Evidence for this in prior literature includes a study from Hurley et al. which found that stress and anxiety during pregnancy were associated with increased overall energy consumption and increased consumption of carbohydrates, fats and proteins (21).

Epidemiology

Stress

Ten epidemiological studies have examined the association between stress and gestational weight gain (11,14,30–37). Eight of the studies were prospective in nature, (11,14,30–33,36,37) one was retrospective (34), and one was cross-sectional (35), and the majority of the studies did not include Hispanic women. Of these, 8 studies found no association (11,30–36), one found that stress was inversely associated with GWG (37), and one found that experiencing a high stress event during pregnancy was associated with increased risk of excessive GWG (14).

The physical symptoms of pregnancy can be misinterpreted as stress, so a measure of stress that specifically validated for use during pregnancy is necessary. Only 3 of the 10 studies used the Perceived Stress Scale (PSS), a validated measure during pregnancy, to measure stress (11,31,33). Only one of the studies examined stress at more than one time point during pregnancy (31). The time point during which stress was measured varied widely between all 10 studies, including the year prior to pregnancy, early pregnancy, late pregnancy and just before delivery. The way GWG was operationalized also varied widely between the 10 studies. Three of the studies examined GWG as a continuous outcome (30,32,37), three used categorizations of GWG (such as quartiles) (14,34,36), and four used IOM categorization of recommended weight gain as the outcome (11,31,33,35). None of the studies considered rate of GWG, a measure that is not confounded by length of gestation.

The most recent study to examine the association between stress and GWG was a prospective cohort study conducted by Webb et al. among a sample of 1,605 primarily non-Hispanic white women in the Pregnancy, Infection and Nutrition study (31). Stress was measured using the Perceived Stress Scale (PSS) at 17-22 weeks gestational age and 27-30 weeks gestational age. Total GWG was abstracted from medical records. Overall, stress was not associated with GWG after adjusting for pre-pregnancy body mass index (BMI) and other maternal, sociodemographic, dietary, and physical activity covariates (31). At 17-22 weeks gestational age, high stress was not associated with increased risk of inadequate weight gain (RR=1.01, 95% CI 0.8-1.3) nor increased risk of excessive weight gain (RR=0.99, 95% CI 0.9-1.1), as compared to low stress. Similarly, at 27-30 weeks gestational age, high stress was not associated with increased risk of inadequate

weight gain (RR=1.02, 95% CI 0.8-1.2) nor increased risk of excessive weight gain (RR=1.01, 95% CI 1.0-1.1), as compared to low stress.

Anxiety

Four epidemiological studies have examined the association between anxiety and GWG (30–32,38). Three of the studies were prospective cohort studies (30–32), and one was a randomized controlled trial (38). One of these studies found that anxiety was associated with increased risk of inadequate GWG (30), while 3 of the studies found no association between anxiety and GWG (31,32,38). Only one study examined both inadequate and excessive GWG (31). Two of the studies assessed anxiety at 2 time points during pregnancy (31,38). All of the studies used total GWG as the outcome of interest, either as a continuous (30,32) or categorical variable (31,38). Prior research on anxiety, similarly to prior research on stress, failed to include rate of GWG, an outcome that is not confounded by length of gestation. The studies were all conducted in primarily non-Hispanic samples. For example, in the two studies that reported the percent of Hispanic participants, Hispanic women comprised 9.2% (31) or 2% (32) of the sample.

In their prospective cohort study described above, Webb et al. used the Speilberger State-Trait Anxiety Inventory (STAI) to also analyze the association between anxiety and GWG among women in the Pregnancy, Infection and Nutrition Study (31). Trait anxiety was assessed via the STAI at <20 weeks gestational age and state anxiety was assessed via the STAI at <20 weeks gestational age and 24-29 weeks gestational age. Anxiety was categorized into low, moderate and high tertiles.

After adjusting for pre-pregnancy body mass index (BMI) and other maternal, sociodemographic, dietary and physical activity covariates, neither high trait anxiety or

moderate trait anxiety was significantly associated with increased risk of inadequate weight gain (RR=1.02, 95% CI 0.8-1.2 and RR=1.06, 95% CI 0.9-1.3, respectively) nor increased risk of excessive weight gain (RR=1.01, 95% CI 1.0-1.1 and RR=1.01, 95% CI 1.0-1.1, respectively), as compared to low trait anxiety.

This study was limited by small numbers of women who did not gain within IOM guidelines, which may have resulted in reduced power. Additionally, as noted previously, the sample was predominately non-Hispanic white.

Hypotheses

Specific Aim 1: To evaluate the association between stress during early-, mid-, and late pregnancy and GWG in a population of Hispanic women.

Hypothesis 1a: Stress during pregnancy is positively associated with rate of GWG in 2nd and 3rd trimesters and with increased risk of not meeting IOM guidelines for rate of GWG in 2nd and 3rd trimesters.

Hypothesis 1b: Stress during pregnancy is positively associated with total GWG and with increased risk of not meeting IOM guidelines for total GWG.

Specific Aim 2: To evaluate the association between anxiety during early-, mid-, and late pregnancy and GWG in a population of Hispanic women.

Hypothesis 2a: Anxiety during pregnancy is positively associated with rate of GWG in the 2nd and 3rd trimesters and with increased risk of not meeting IOM guidelines for rate of GWG in the 2nd and 3rd trimesters.

Hypothesis 2b: Anxiety during pregnancy is positively associated with total GWG and with increased risk of not meeting the IOM guidelines for total GWG.

Methods

Study Design

We examined the association between stress, anxiety and GWG using data from Proyecto Buena Salud (PBS), a prospective cohort study of Hispanic prenatal care patients at Baystate Medical Center in Springfield, Massachusetts from January 2006 through October 2010. Bilingual interviewers (Spanish and English) recruited patients at a prenatal care visit early in pregnancy (before 20 weeks gestation). Pregnant women were informed of the aims and procedures of the study and provided written informed consent approved by the Institutional Review Boards of the University of Massachusetts Amherst and Baystate Medical Center. The study consisted of three structured interviews, conducted in Spanish or English (based on the participant's preference) as well as medical record review. The first interview (early pregnancy) occurred at the time of enrollment (between 6 and 18 weeks gestation). The second interview (mid-pregnancy) occurred between 18.1 and 26 weeks gestation. The final interview (late pregnancy) occurred between 26.1 and 43 weeks gestation (Figure 1). Medical records were abstracted after delivery for medical and obstetrical history.

Study Population

Women were eligible to participate in PBS if they were of Puerto Rican or Dominican Republic (the Caribbean Islands) heritage, defined as having been born in the Caribbean Islands, having a parent who was born in the Caribbean Islands or having two

grandparents who were born in the Caribbean Islands. Exclusion criteria included 1) taking medications thought to adversely influence glucose tolerance, 2) multiple gestation, 3) history of diabetes, hypertension, heart disease or chronic renal disease and 4) <16 or >40 years of age at enrollment. For the purposes of the current analysis, women were excluded if information on GWG was missing (defined as missing information on pre-pregnancy body mass index (BMI)), or if they had a spontaneous or therapeutic abortion, a stillbirth, a preterm birth or a late term birth, as their GWG was not comparable to women who were pregnant to term, 37-42 weeks gestation.

Exposure Assessment

Psychosocial stress was measured at early, mid- and late-pregnancy using Cohen's Perceived Stress Scale (PSS-14). The PSS-14 consists of 14 questions that address control over the demands of daily life, and includes questions such as "How often have you felt you were on top of things" and "How often have you felt nervous and stressed?" Participants answered each question on a 5-point scale, ranging from never (0) to always (4). Positively worded items were reverse scored and the total rating over the 14 questions was summed for a total stress score ranging from 0-56. Higher scores indicate more perceived psychosocial stress. At each pregnancy time point, stress was analyzed as a continuous variable and was additionally categorized into quartiles (Table 1.1).

The PSS has been shown to have adequate reliability in a general population (alpha=0.78)(39,40) and in a three sample study by Cohen et al (alpha=.085) (41,42). Cohen et al also found the PSS to be correlated with depressive symptoms (r=0.65-0.76) (41). The PSS has been validated among pregnant women. A 10-item version of the PSS

was internally consistent (r=0.90) and valid when compared against the Edinburgh Postnatal Depression Scale (r=0.67, p<.001) (43). The Spanish version of the PSS has adequate test-retest reliability (r=0.73), internal consistency (alpha=0.81), and validity with the Hospital Anxiety and Depression Scale (HADS) (r=0.71 for HADS-distress and r=0.66 for HADS-anxiety) (40).

Anxiety was measured using the Spielberger State-Trait Anxiety Inventory (STAI), which was administered by trained interviewers during early-, mid- and late pregnancy. The STAI-trait anxiety scale is designed to measure relatively stable individual differences in proneness to anxiety and consists of 20 statements about how the participant generally feels, including "I am a steady person" and "I lack self-confidence." The STAI-state anxiety scale is designed to measure conditional levels of anxiety, dependent on environmental influences, and consists of 20 statements about how the participant feels at the time they are being interviewed, including "I feel satisfied" and "I feel jittery." For both the STAI-trait and the STAI-state anxiety scales, participants answer each question on a 4-point scale ranging from never (1) to almost always (4). Positively worded items were reverse scored and the total rating over the 20 questions was summed for a total stress score ranging from 20-80. Higher scores indicate higher levels of anxiety. Trait anxiety is measured during early pregnancy, and state anxiety is measured during mid- and late-pregnancy. At each pregnancy time point, anxiety was analyzed as a continuous variable, and was additionally categorized into quartiles (Table 1.1).

The STAI has been widely used, including during pregnancy (11,30,31,44). Internal consistency, measured in a non-pregnant population, ranges from 0.86-0.97

(45,46). A validity study found the state anxiety scale has a high degree of internal consistency, with every item significantly correlated in test-retest (correlation coefficients ranging from r=0.38-0.68). The trait anxiety scale also has a high degree of internal consistency, with 18 of the 20 items significantly correlated in test-retest (correlation coefficients ranging from r=0.28-0.64). Overall scale scores were highly correlated (r=0.86) (46). The scale was also found to have excellent discrimination when used under both low stress and high stress situations (46). The trait anxiety scale correctly measured 5 of 8 domains for generalized anxiety disorder, based on the diagnostic criteria included in the DSM-IV (47). Additionally, the STAI has been validated among pregnant women. Gunning et al. found state anxiety and trait anxiety significantly associated with open-ended responses to how women feel about their pregnancy ($F(2,174)=9.699$, $p<.001$ and $F(2,174)=8.877$, $p<.001$, respectively) (48). The STAI has been adapted for use in Spanish, and has been validated by TEA Editions (49).

Outcome Assessment

A clinical weight was recorded for participants at each prenatal care visit during their pregnancy and at the time of delivery. The measured weights and the corresponding gestational age at which the weights were measured were abstracted from medical records.

Rate of GWG in the 2nd and 3rd trimesters was calculated as the difference between weight at delivery and weight at the prenatal visit closest to 13 weeks gestation, divided by total weeks of gestation between weight at delivery and the weight at the prenatal visit closest to 13 weeks gestation. GWG is assumed to minimal in the first trimester (2.2 – 4.4 lbs) and then linear in the second and third trimesters (1). Rate of

weight gain was analyzed as a continuous variable and was additionally categorized according to IOM guidelines: inadequate, within guidelines and excessive. IOM guidelines indicate that after the first trimester, women with a BMI <18.5 kg/m^2 are advised to gain 1.0-1.3 lbs per week, women with a BMI of 18.5-24.9 kg/m^2 are advised to gain 0.8-1.0 lbs per week, women with a BMI of 25.0-29.9 kg/m^2 are advised to gain 0.5-0.7 lbs per week, and women with a BMI ≥30.0 kg/m^2 are advised to gain 0.4-0.6 lbs per week (Table 1.2) (1).

Total GWG was abstracted from medical records after delivery, and was calculated as the difference between measured maternal weight at delivery and pre-pregnancy weight (as self-reported in medical records). When pre-pregnancy weight was not available from medical records, self-reported pre-pregnancy weight was used from the interview in early pregnancy. GWG was analyzed as a continuous variable. GWG was additionally categorized according to IOM guidelines: inadequate (gaining less than the recommended minimum), within guidelines (gaining within the recommendation), and excessive (gaining more than the recommended maximum). IOM guidelines vary according to pre-pregnancy BMI and are as follows: women with a BMI <18.5 kg/m^2 are advised to gain 28-40 lbs, women with a BMI of 18.5-24.9 kg/m^2 are advised to gain 25-35 lbs, women with a BMI of 25.0-29.9 kg/m^2 are advised to gain 15-25 lbs, and women with a BMI ≥30.0 kg/m^2 are advised to gain 11-20 lbs (Table 1.2) (1).

Data on delivery weight was collected from medical records from a trained abstractor, and is considered the "gold standard" (1). Pre-pregnancy weight (self-reported at the first prenatal care visit) was also abstracted from medical records after delivery. Self-reported pre-pregnancy weight is commonly used in epidemiologic studies of GWG

because preconception weight measures typically do not exist in medical record data and the IOM presents it as a practical method of measuring pre-pregnancy weight (1). Prior studies have found that self-reported pre-pregnancy weight is highly correlated with measured pre-pregnancy weight (r=0.95, r=0.98) and that self-reported pre-pregnancy weight is underreported by about 1kg on average (50–52). Further, BMI calculated from self-reported weight and measured weight had good agreement (76.4% for underweight, 85.3% for normal weight, 75.7% for overweight, 71.9% for obese and 93.1% for severely obese) (53).

Covariate Assessment

Marital status, education, income, number of adults and children in the household, smoking and alcohol consumption during early pregnancy, morning sickness during early pregnancy, total physical activity at early, mid- and late pregnancy (measured via the Pregnancy Physical Activity Questionnaire) (54), depression at early, mid- and late pregnancy (measured via the Edinburgh Depression Scale) (55,56), acculturation (measured via the Psychological Acculturation Scale) (57), and generation in the United States were obtained through interviews. Gravidity, parity, age, pre-pregnancy BMI and gestational age at delivery were abstracted from medical records. Covariates were selected based on inclusion in prior literature and biological relevance (11,14,30–38). Final multivariable models will include important confounders included in prior literature (i.e., age and pre-pregnancy BMI) and potential confounders that change the estimate by more than 10%. In addition, the final models examining stress and GWG will be run with and without adjusting for anxiety, and final models examining anxiety and GWG will be run with and without adjusting for stress, as stress and anxiety are correlated.

Data Analysis

To address both specific aim 1 and 2, we calculated the number and percent of participants included in the study sample, the distribution of stress during early-, mid-, and late pregnancy, the distribution of anxiety during early-, mid-, and late pregnancy, and the distribution of GWG.

Potential confounders were assessed by cross-tabulating covariates by stress in early, mid and late pregnancy, by anxiety during early-, mid-, and late pregnancy, and by GWG. Chi-square tests for categorical variables and t-tests for continuous variables were used, and associated p-values are reported. Fisher's Exact Test was used in the case of small cell sizes.

Unadjusted linear regression models were used to model associations between stress and anxiety in early, mid and late pregnancy and the continuous GWG outcomes (total GWG and rate of GWG). Regression coefficients, standard errors and p-values are reported. Unadjusted logistic regression models were used to model the association between stress or anxiety in early, mid and late pregnancy and the categorical GWG outcomes (adherence to IOM guidelines regarding total weight gain and adherence to IOM guidelines regarding rate of weight gain). Relative risks and 95% confidence interval are reported.

The final models were developed using multivariable linear regression models and multinomial logistic regression models, adjusting for important covariates and confounders (as outlined previously) and covariates causing a 10% or greater change in estimate. Regression coefficients, standard errors and p-values, or relative risks and 95% confidence intervals are reported. All analyses were complete case analyses.

Results

Stress

A total of 1,583 participants were recruited into PBS. The final sample for analysis included 1,308 Hispanic women, after removing 74 women who were missing information on GWG, 61 women who had a spontaneous or therapeutic abortion, 16 women who had a stillbirth, 123 women who had a preterm birth and 1 woman who had a late term birth (Table 1.3).

The average weight gain among participants was 30.8 pounds (SD=16.2 lbs). More than half of the women (51.7%) gained excessive weight over their entire pregnancy. Conversely, just under 20% of women failed to gain enough weight as recommended for them by the IOM (Table 1.4). Women gained 1.0 pounds per week, on average (SD=0.05), and 63% of women gained weight at a more rapid rate than recommended by the IOM (Table 1.4).

Stress scores ranges from 3 to 54 (possible range: 0-56). On average, stress was lower in late pregnancy than in early pregnancy. The average stress score was 26.1 in early pregnancy (SD=7.0), 25.2 in mid pregnancy (SD=7.4) and 23.5 in late pregnancy (SD=7.7). (Table 1.5).

We evaluated participant characteristics according to stress in early (Table 1.6a), mid (Table 1.6b) and late pregnancy (Table 1.6c). Women with income less than $15,000 per year were more likely to be in the highest quartile of stress in early, mid pregnancy, as compared to women earning more than $15,000 per year (Tables 1.6a and 1.6b). In early pregnancy, women experiencing morning sickness and women who smoked more than 10 cigarettes a day were most likely to be in the highest quartile of stress (Table

1.6a). Those experiencing probable major depression were also in the highest quartile of stress in early, mid and late pregnancy (Tables 1.6a, 1.6b and 1.6c). The same was true for anxiety; women with the highest levels of anxiety were more likely to be in the highest quartile of stress in early, mid and late pregnancy (Tables 1.6a, 1.6b and 1.6c). In mid pregnancy, women with low acculturation were in the highest quartile of stress (Table 1.6b).

We also evaluated participant characteristics according rate of GWG and adherence to IOM guidelines for rate of GWG (Table 1.7a), and total GWG, adherence to IOM guidelines for total GWG (Table 1.7b). Covariates associated with higher rate of GWG included younger age, fewer children in the household, not having experienced morning sickness, not smoking, consuming any alcohol during early pregnancy, having a pre-pregnancy BMI in the normal range, and lower gravidity and parity (Table 1.7a). Covariates associated with greater total GWG included younger age, higher yearly income, not experiencing morning sickness, not smoking and not consuming alcohol consumption, having a pre-pregnancy BMI in the normal range, lower parity, and gravidity (Table 1.7b). Covariates significantly associated with adherence to IOM recommendations for total GWG were slightly different. In particular, women with inadequate weight gain were more likely to have less than a high school degree as compared to women with excessive gain (Table 1.7b).

In bivariate analyses of stress in early, mid and late pregnancy and rate of GWG, no association was found for stress in early and mid-pregnancy. We also found no association between stress in late pregnancy as a continuous variable and rate of GWG, but women in the highest quartile of stress in late pregnancy gained weight at a

significantly lower rate than women in the lowest quartile of stress in late pregnancy (B=-0.106, p=0.044). This association remained after adjusting for important covariates (age, pre-pregnancy BMI, total activity in late pregnancy, probable major depression in late pregnancy and gravidity) (B=-0.155, p=0.006) and after additionally adjusting for anxiety in late pregnancy (B=-0.131, p=0.037). Furthermore, as stress in late pregnancy increased from the lowest to the highest quartile, women gained weight more slowly after adjusting for important covariates (p for trend = 0.010) although after additionally adjusting for anxiety in late pregnancy, this trend was no longer significant (p for trend = 0.063) (Table 1.8a).

In bivariate analyses, stress in early, mid and late pregnancy was not associated with total GWG, although there was a suggestion that stress in early pregnancy was negatively associated with total GWG (B=-0.16, p=0.053). This suggestion remained after adjusting for important covariates (age, pre-pregnancy BMI, total activity in early pregnancy, probably major depression in early pregnancy and gravidity), but not after additionally adjusting for anxiety in early pregnancy (Table 1.9a). When examining stress in quartiles, we found that women in the highest quartile of stress in early pregnancy gained less total weight than women in the lowest quartile (B=-3.54, p=0.029). The finding that women in the highest quartile of stress in early pregnancy gained less weight than women in the lowest quartile remained (B=-4.00, p=0.031) after adjusting for important covariates (listed above). It was no longer significant, however, after also adjusting for anxiety in early pregnancy (Table 1.9a). We also found that women in the third quartile of stress in mid-pregnancy gained significantly less weight than women in the first quartile of stress in mid-pregnancy (B=-3.65, p=0.049) after adjusting for

important covariates (listed above) but this finding also became nonsignificant after additionally adjusting for anxiety in mid-pregnancy (Table 1.9a).

We found no significant association between stress in early, mid and late pregnancy and adherence to IOM guidelines for rate of GWG (Table 1.8b), or between in early, mid and late pregnancy and adherence to IOM guidelines for total GWG (Table 1.9b) regardless of if we analyzed the association using stress as a continuous variable or in quartiles.

Anxiety

The range of possible values for the STAI was 20-80, with higher scores indicating higher anxiety. In early, mid and late pregnancy, women scored over nearly the entire range (20-76, 20-77 and 20-79, respectively). Anxiety scores decreased, on average, from early to mid to late pregnancy (M=40.2, SD=10.3, M=34.0, SD=11.5, and M=32.9, SD=11.2, respectively) (Table 1.10).

We evaluated participant characteristics with regard to trait anxiety in early pregnancy (Table 1.11a), state anxiety in mid pregnancy (Table 1.11b) and state anxiety in late pregnancy (Table 1.11c). In early pregnancy, higher trait anxiety was significantly associated with younger age, being single, divorced or widowed, lower education, experiencing morning sickness, smoking more than 10 cigarettes per day in early pregnancy, probable major depression and high stress (Table 1.11a).

In mid and late pregnancy, fewer participant characteristics were significantly associated with anxiety. Probable major depression and high levels of stress remained associated, however, with women with the highest depression and stress also having the highest levels of anxiety (Table 1.11b and 1.11c).

In bivariate analyses, increasing trait anxiety in early pregnancy was associated with lower rate of GWG (B=-0.004, p=0.036). This association remained after adjusting for important covariates (age, pre-pregnancy BMI, depression in early pregnancy and gravidity) (B=-0.005, p=0.022) and after additionally adjusting for stress in early pregnancy (B=-0.006, p=0.042). The same association was found when examining trait anxiety in quartiles. In bivariate analyses, women in the highest quartile of trait anxiety gained weight more slowly than women in the lowest quartile of trait anxiety (B=-0.108, p=0.031). This association remained after adjusting for important covariates (age, pre-pregnancy BMI, depression in early pregnancy, and gravidity) (B=-0.138, p=0.021) but was no longer significant after additionally adjusting for stress in early pregnancy. State anxiety in mid pregnancy was not associated with rate of GWG, but there was a trend in late pregnancy that women in the highest quartiles of state anxiety gained weight slower than women in the lowest quartiles of state anxiety (p for trend = 0.032). The trend remained after adjusting for important covariates (p for trend = 0.036) but was no longer significant after additionally adjusting for stress in late pregnancy (Table 1.12a).

Anxiety was also associated with total of GWG. In bivariate analyses, trait anxiety in early pregnancy was strongly associated with total GWG. Higher levels of trait anxiety as a continuous variable was associated with lower total weight gain (B=-0.17, p=0.002). Women in the highest quartile of trait anxiety gained less weight than women in the first quartile of trait anxiety (B=-4.33, p=0.008), and as anxiety increased from the first quartile to the fourth, total weight gained was lower (p for trend = 0.011). These effects remained after adjusting for important covariates (listed above); higher levels of trait anxiety were associated with lower GWG (B=-0.18, p=0.006) and women in the

highest quartile for trait anxiety gained less weight than women in the lowest quartile (B=-4.22, p=0.028, p for trend = 0.044). The association was no longer significant, however, after adjusting for stress in early pregnancy. State anxiety in mid and late pregnancy was not associated with total GWG (Table 1.13a).

We found no significant association between anxiety in early, mid and late pregnancy and adherence to IOM guidelines for rate of GWG (Table 1.12b) or between anxiety in early, mid and late pregnancy and adherence to IOM guidelines for total GWG (Table 1.13b), regardless of whether anxiety was parameterized as a continuous variable or in quartiles.

Discussion

In summary, in this prospective cohort study among Hispanic prenatal care patients from the Caribbean Islands, we found after adjusting for important covariates including age and pre-pregnancy BMI that high stress in late pregnancy was associated with lower rate of GWG and that high stress in early pregnancy was associated with lower total GWG. Neither effect was statistically significant after further adjustment for anxiety in the corresponding stage of pregnancy. We did not find evidence for an association between stress and adherence to IOM guidelines for rate of GWG or between stress and adherence to IOM guidelines for total GWG. Similarly, we found after adjusting for important covariates that high anxiety in late pregnancy was associated with a lower rate of GWG and that high anxiety in early pregnancy was associated with lower total GWG. After additionally adjusting for stress in the corresponding stage of pregnancy, the association between high anxiety in early pregnancy and lower total GWG remained but the association between high anxiety in late pregnancy and lower rate of GWG was no longer

significant. We did not find evidence of an association between anxiety and adherence to IOM guidelines for rate of GWG or between anxiety and adherence to IOM guidelines for total GWG.

Our findings that high stress in pregnancy is associated with lower rate of GWG and lower total GWG are consistent with and expand upon the results of the prospective cohort study from Picone et al. (37). The study included 60 pregnant women on welfare and/or enrolled in the Women, Infants and Children (WIC) program, 38% of whom were Hispanic. The authors found that high stress during pregnancy was negatively correlated with gestational weight gain ($r=-0.37$, $p<.01$). Similarly, we found that high stress in early pregnancy is associated with lower total GWG ($B=-0.16$, $p=0.053$ for stress as a continuous exposure and $B=-4.00$, $p=0.031$ for highest quartile of stress compared to the lowest quartile of stress), and high stress in late pregnancy is associated with a lower rate of GWG ($B=-0.131$, $p=0.037$ for the highest quartile of stress compared to the lowest quartile of stress).

Our findings that high anxiety in early pregnancy was associated with reduced total GWG are in agreement with, and again, expand upon the results of the prospective cohort study from Hickey et al. (30). The study included 806 high-risk, low-income women. The women were primarily black (66.5%) and the remaining women were non-Hispanic white (33.5%). The authors found that non-Hispanic white women in the highest quartile of anxiety had an increased risk of low weight gain (OR=2.5, 95% CI 1.2-5.0) compared to women in the lowest quartile of anxiety, and that there was no association between anxiety and risk of low weight gain among black women (OR=1.0, 95% CI 0.6-1.6). Similarly, we found that trait anxiety, measured in early pregnancy, is

associated with reduced total GWG (B=-0.18, p=0.006) and reduced rate of GWG (B=-0.006, p=0.042). We found the same pattern of associations for high anxiety compared to low anxiety when parameterized into quartiles (B=-4.22, p=0.044 for total GWG and B=-0.138, p-0.021 for rate of GWG).

In contrast, our findings differ from the majority of prior studies which found no association between stress, anxiety, and measures of GWG. Differences in study findings may be a result of how stress or anxiety was measured and/or how GWG was measured. We were able to examine stress and anxiety in early, mid and late pregnancy. In contrast, only one of the prior studies measured stress more than once during pregnancy (31) and two measured anxiety more than once (31,38). Therefore, we were able to gain a unique understanding of when during pregnancy women's weight gain was most sensitive to stress and anxiety. Additionally, we measured stress with the validated PSS, which only three of nine studies with contrasting results used (11,31,33), and anxiety with the validated STAI. Finally, differences in our findings could have occurred due to the different populations under study. It is likely that differences in diet, lifestyle, sociocultural factors, as well as healthcare utilization and access among different populations may modify the association between stress and anxiety and patterns of GWG.

Although there is no direct research on the biological mechanism linking stress or anxiety to GWG, prior research indicates that hypo- or hyper-activation of the HPA axis may lead to disruptions in hormone levels that result in reduced efficiency to synthesis adipose tissue and inadequate GWG. Further, high levels of stress and/or anxiety may contribute to unhealthy coping behaviors that make it difficult to gain weight.

Our study had several strengths. We examined the association between stress and anxiety and GWG among pregnant Hispanic women from the Caribbean Island, a traditionally underrepresented population. Our study is prospective in nature, allowing us to assess temporality in the association between stress and anxiety and GWG. We measured of stress and anxiety with validated instruments three times over the course of pregnancy and examined the association of both with rate of GWG and total GWG.

However, our study also had several limitations. Firstly, a nondifferential misclassification of the exposure, stress, could have resulted from errors in the interviewing process. It is possible that women over- or under-reported their perceived level of stress, as feeling stressed during pregnancy may be a sensitive issue for some women. The structured format of the interviews and the previous validation of the PSS, however, minimizes the threat of misclassification. Further, due to the prospective nature of the study, we do not expect women's reporting of their perceived stress to be influenced by their weight gain. Therefore, any misclassification that did occur is likely to be nondifferential and minor and would bias the results towards the null. Similarly, nondifferential misclassification of anxiety, could also have resulted from errors in the interviewing process. Again, it is possible that women over- or under-reported their tendency to feel anxious or their current feelings of anxiety, as feeling anxious during pregnancy may be a sensitive issue for some women. The structured format of the interviews and use of a validated scale, however, minimizes the threat of misclassification. Again, we expect any misclassification to be nondifferential due to the prospective nature of the study. Any misclassification that did occur is likely to be nondifferential and minor, and would bias the results towards the null.

The outcome, GWG, is ascertained through abstraction of medical records. Self-reported pre-pregnancy weight is recorded by health professionals at the first prenatal visit. As previously discussed, self-reported pre-pregnancy weight has been found to differ from measured pre-pregnancy weight, and this may result in some nondifferential misclassification of both total gestational weight gained and adherence to IOM guidelines if pre-pregnancy BMI is misclassified. Women both under- and over-report pre-pregnancy weight. In addition, weight is measured at every prenatal visit and upon admission to the hospital during labor, although for clinical and not research purposes. Misclassification could occur due to scale calibration issues, women wearing clothing and shoes of various weights. The misclassification in pre-pregnancy weight may lead to misclassification in pre-pregnancy BMI. There are therefore multiple opportunities for misclassification of the outcome. Given that some misclassification of pre-pregnancy weight is likely, it is likely that the outcome is misclassified, and therefore the results of the study will be biased toward the null. We expect the impact of this to be modest, because prior studies have found that self-reported pre-pregnancy weight is highly correlated with measured pre-pregnancy weight.

Secondly, a selection bias could have occurred if there was differential loss to follow-up. However, differential loss to follow-up is unlikely due to the ascertainment of outcome through abstraction of medical records, and would have been minimal, as eligibility criteria were limited to those planning to deliver at the study hospital. Further, in many cases, the medical records of participants delivering at another hospital were requested and obtained.

Finally, given the number of variables examined, we cannot rule out chance as explanation for the observed significant findings. In this case, it is critical that the interpretation of the findings from each individual model be interpreted conservatively and in light of a feasible biologic rationale. However, only a minority of p values were statistically significant. In addition, the stress and anxiety cut-points were consistent with prior literature (14,34,36),, and GWG variables used have a likely potential physiological connection with the outcome.

We tested a number of variables as confounders that have been identified in previous studies and important confounders were included in final multivariate models. Age, pre-pregnancy BMI and gravidity were always included in final models, as was depression in the corresponding stage of pregnancy and stress or anxiety, depending on the exposure. Residual confounding is possible if the confounders are inaccurately measured. There is also the possibility for residual confounding by unmeasured confounders. For example, participant's food security is not measured. Food security is positively associated with both stress and weight gain (and therefore, likely associated with GWG) (58,59). Our inability to control for food security, if it is a confounder, would result in an overestimate of the relative risk. Although we are not able to control for food security, we are able to control for income and education, which are likely to at least partially explain food security.

The results of this study may be generalized to pregnant women from the Caribbean Islands. Our results may not be generalized to pregnant women who have multiple births, as our study was restricted to mothers with singleton births. Multiple births may increase stress and anxiety, and is associated with different patterns of GWG.

However, there is little reason to believe that the biological mechanism for the association between stress or anxiety and weight gain would differ according to number of births. The psychosocial link between stress and anxiety and GWG may vary by racial/ethnic group due to cultural differences in the triggers for, and manifestations of, these psychosocial factors. The distribution of stress and anxiety among Hispanic women from Puerto Rico and the Dominican Republic may involve a different spectrum from that found among non-Hispanic women or those from other Hispanic subgroups (e.g., Mexican Americans). In other words, the range of high and low stress scores may be much higher than those found among non-Hispanic women. Sociocultural as well as socioeconomic differences among various ethnicities may influence the mechanism for the association between stress and anxiety and GWG. Hence, our findings may not be generalized to non-Hispanic populations or other Hispanic subgroups.

In summary, we found that high stress and anxiety in late pregnancy was associated with lower rate of GWG and that high stress and anxiety in early pregnancy was associated with lower total GWG. These findings suggest that early and late pregnancy are critical periods to target stress and anxiety among Hispanic pregnant women from the Caribbean Islands, as they relate to GWG, and interventions to reduce stress and anxiety should include counseling on maintaining healthy GWG. Further prospective research should examine if differing patterns of stress and anxiety during pregnancy impact rate of GWG and total GWG.

Figure 1. Diagram of Interview Schedule: Proyecto Buena Salud, 2006-2010.

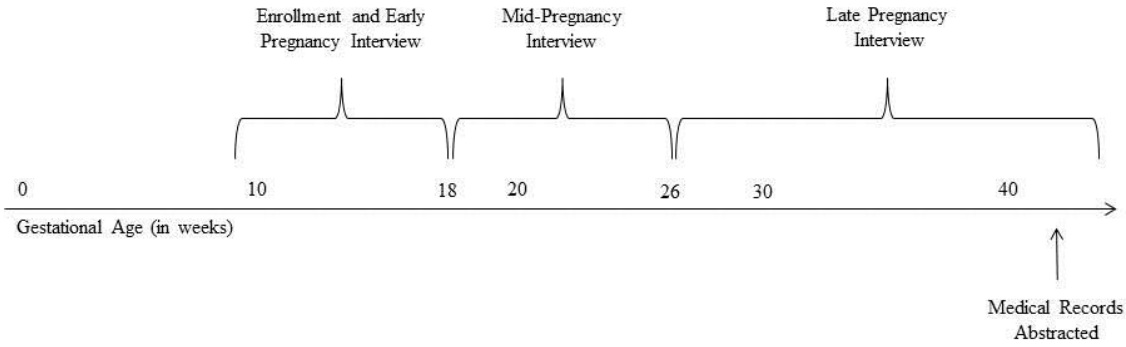

Table 1.1. Classification of Study Variables: Proyecto Buena Salud, 2006-2010.

Name	Description	Type
Outcome Variables		
rate_gwg	Rate of Gestational Weight Gain	Continuous
iom_rate	Met IOM Rate Gestational Weight Gain 0=within recommendations 1=inadequate 2=excessive	Categorical
tot_gwg	Total Gestational Weight Gain	Continuous
iom_totgwg	Met IOM Total Gestational Weight Gain 0=within recommendations 1=inadequate 2=excessive	Categorical
Exposure Variables		
ta	Trait Anxiety, Early Pregnancy	Continuous
ta_quart	Trait Anxiety, Early Pregnancy 0=1st quartile 1=2nd quartile 2=3rd quartile 3=4th quartile	Categorical
sa2	State Anxiety, Mid-Pregnancy	Continuous
sa2_quart	State Anxiety, Mid-Pregnancy 0=1st quartile 1=2nd quartile 2=3rd quartile 3=4th quartile	Categorical
sa3	State Anxiety, Late Pregnancy	Continuous
sa3_quart	State Anxiety, Late Pregnancy 0=1st quartile 1=2nd quartile 2=3rd quartile 3=4th quartile	Categorical
pss1	Stress, Early Pregnancy	Continuous
pss1_quart	Stress, Early Pregnancy 0=1st quartile 1=2nd quartile 2=3rd quartile 3=4th quartile	Categorical

Table 1.1., continued.

Name	Description	Type
pss_quart	Stress, Mid-Pregnancy	Continuous
pss2_quart	Stress, Mid-Pregnancy 0=1st quartile 1=2nd quartile 2=3rd quartile 3=4th quartile	Categorical
pss3	Stress, Late Pregnancy	Continuous
pss3_quart	Stress, Late Pregnancy 0=1st quartile 1=2nd quartile 2=3rd quartile 3=4th quartile	Categorical
Covariates		
age	Age 1=16-19 2=20-24 3=25-29 4=≥30	Categorical
married	Marital Status 1=Single/Separated/Divorced/Widowed 2=Married 3=Refused	Categorical
ed	Education 1=Less than high school 2=High school graduate or GED 3=Post high school	Categorical
income	Income 1=≤$15,000 2=>$15,000-$30,000 3=>$30,000 4=don't know/refuse	Categorical
adults	Number of Adults in Household 0=1 1=1 2=2 3=≥3	Categorical

Table 1.1., continued.

Name	Description	Type
kids	Number of Children in Household 0=1 1=1 2=2 3=≥3	Categorical
acc_status	Acculturation 1=low (1-<3) 2=high (≥3)	Dichotomous
generation	Generation in US 1=Born in PR/DR 2=Parent born in PR/DR 3=Grandparent born in PR/DR	Categorical
c_msick	Morning Sickness in Early Pregnancy 0=no 1=yes	Dichotomous
pregsmoke_early	Smoking, Early Pregnancy 0=None 1=<=10 cigs/day 2=Over 10 cigs/day	Categorical
pregalc_early	Alcohol Consumption During Early Pregnancy 0=no 1=yes	Dichotomous
eds2_1	Probable Major Depression, Early Pregnancy 0=no 1=yes	Dichotomous
eds2_mid	Probable Major Depression, Mid-Pregnancy 0=no 1=yes	Dichotomous
eds2_late	Probable Major Depression in Late Pregnancy 0=no 1=yes	Dichotomous
GA_delivery	Gesational Age of Infant at Delivery	Continuous
PA_early	Total Physical Activity, Early Pregnancy (MET h	Continuous
PA_mid	Total Physical Activity, Mid Pregnancy (MET hrs	Continuous

Table 1.1., continued.

Name	Description	Type
PA_late	Total Physical Activity, Late Pregnancy (MET hr	Continuous
bmi_new	Pre-Pregnancy BMI 1= <18.5 2= 18.5-<25 3= 25-<30 4= ≥30	Categorical
gravidity	Gravidity 0=0 previous pregnancies 1=1 previous pregnancy 2=2 or more previous pregnancies	Categorical
parity	Parity 0=0 live births 1=1 live birth 2=≥2 live births	Categorical

Table 1.2. Institute of Medicine Guidelines for Total Gestational Weight Gain and Rate of Weight Gain in Second and Third Trimesters.

	Total Weight Gain	Rate of Weight Gain, 2nd and 3rd Trimesters
Pre-Pregnancy BMI		
Underweight (< 18.5)	28-40	1.0-1.3
Normal Weight (18.5-24.9)	25-35	0.8-1.0
Overweight (25.0-29.9)	15-25	0.5-0.7
Obese (≥ 30.0)	11-20	0.5-0.6

Table 1.3. Number and Percent in Final Sample: Proyecto Buena Salud, 2006-2010.

Original Study Sample	1583	
Excluded		
Missing information on gestational weight gain	37	2.3%
Spontaneous or therapeutic abortion	65	4.1%
Stillbirth	17	1.1%
Preterm birth (<37 weeks GA)	124	7.8%
Late term birth (>42 weeks GA)	1	0.1%
Final Sample Size	1339	84.6%

Table 1.4. Distribution of Gestational Weight Gain Variables: Proyecto Buena Salud, 2006-2010.

Rate of Gestational Weight Gain (lbs/week)	940	1.0 (0.5)
Adherence to IOM Guidelines for Rate of Weight Gain	940	
Inadequate Gestational Weight Gain	187	19.9%
Within Recommendations	157	16.7%
Excessive Gestational Weight Gain	596	63.4%
Total Gestational Weight Gain (lbs)	1197	30.8 (16.2)
Adherence to IOM Guidelines for Total Weight Gain	1181	
Inadequate Gestational Weight Gain	232	19.6%
Within Recommendations	338	28.6%
Excessive Gestational Weight Gain	611	51.7%

Table 1.5. Distribution of Stress (Early, Mid and Late Pregnancy): Proyecto Buena Salud, 2006-2010.

	N	Range	M (SD)
Stress (early pregnancy)	819	(3-48)	26.1 (7.0)
Stress (early pregnancy)	819		
1st quartile	253	(7-22)	17.6 (3.7)
2nd quartile	182	(23-26)	24.5 (1.2)
3rd quartile	202	(27-31)	29.0 (1.3)
4th quartile	182	(32-48)	36.7 (4.8)
Stress (mid-pregnancy)	705	(2-47)	25.2 (7.4)
Stress (mid-pregnancy)	705		
1st quartile	191	(2-20)	15.6 (3.9)
2nd quartile	167	(21-25)	23.2 (1.4)
3rd quartile	178	(26-30)	27.7 (1.4)
4th quartile	169	(31-47)	35.3 (3.5)
Stress (late pregnancy)	701	(2-54)	23.5 (7.7)
Stress (late pregnancy)	701		
1st quartile	210	(2-19)	14.2 (4.2)
2nd quartile	145	(20-23)	21.5 (1.2)
3rd quartile	196	(24-29)	26.7 (1.7)
4th quartile	150	(30-54)	34.6 (4.8)

Table 1.6a. Distribution of Covariates According to Stress, Early Pregnancy: Proyecto Buena Salud, 2006-2010.

	Stress, Early Pregnancy				
	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	p-value
Demographics					
Age					p=0.055
16-19	34.2%	31.7%	33.0%	29.9%	
20-24	32.3%	40.3%	43.2%	42.8%	
25-29	17.7%	15.6%	17.5%	18.7%	
≥30	15.8%	12.4%	6.3%	8.6%	
Marital Status					p=0.818
Single/Separated/Divorced/Widowed	86.4%	88.1%	88.7%	89.1%	
Married	11.7%	9.7%	9.3%	7.6%	
Refused	1.9%	2.2%	2.0%	3.3%	
Education					p=0.105
less than high school	43.2%	43.8%	50.2%	53.8%	
high school graduate or GED	31.7%	33.5%	31.7%	31.7%	
post high school	25.1%	22.7%	18.0%	14.5%	
Income					**p=0.018**
≤$15,000	26.8%	25.4%	35.3%	33.2%	
>$15,000-$30,000	16.7%	18.4%	10.8%	13.0%	
≥$30,000	11.7%	7.0%	5.4%	4.3%	
don't know/refuse	44.7%	49.2%	48.5%	49.5%	
Number of Adults in Household					p=0.549
1	27.8%	24.2%	25.0%	24.3%	
2	47.9%	47.8%	47.1%	42.2%	
≥3	24.3%	28.0%	27.9%	33.5%	
Number of Children in Household					p=0.786
0	20.2%	18.3%	18.8%	19.7%	
1	33.7%	32.2%	37.6%	37.2%	
2	27.8%	23.9%	24.3%	24.0%	
≥3	18.3%	25.6%	19.3%	19.1%	
Acculturation					p=0.300
low (1-<3)	76.9%	82.9%	81.6%	76.7%	
high (≥3)	23.1%	17.1%	18.4%	23.3%	
Generation in US					p=0.190
born in PR/DR	46.2%	52.0%	42.9%	44.3%	
parent born in PR/DR	47.0%	40.7%	52.0%	52.5%	
grandparent born in PR/DR	6.8%	7.3%	5.1%	3.3%	
Characteristics of Pregnancy					
Morning Sickness, Early Pregnancy					**p=0.029**
no	23.2%	27.0%	22.0%	14.5%	
yes	76.8%	73.0%	78.0%	85.5%	
Smoking, Early Pregnancy					**p=0.003**
None	90.2%	90.6%	84.3%	79.0%	
≤10 cigs/day	9.4%	9.4%	13.1%	18.2%	
>10 cigs/day	0.4%	0.0%	2.5%	2.8%	
Alcohol Consumption, Early Pregnancy					p=0.537
no	98.4%	96.7%	97.0%	98.4%	
yes	1.6%	3.3%	3.0%	1.6%	
Probable Major Depression, Early Pregnancy					**p<0.001**
no	98.8%	91.2%	80.9%	50.0%	
yes	1.2%	8.8%	19.1%	50.0%	

Table 1.6a., continued.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	p-value
Probable Major Depression, Mid Pregnancy					**p<0.001**
no	96.9%	87.6%	78.9%	59.8%	
yes	3.1%	12.4%	21.1%	40.2%	
Probable Major Depression, Late Pregnancy					**p<0.001**
no	95.3%	93.6%	85.5%	63.8%	
yes	4.7%	6.4%	14.5%	36.2%	
Anxiety, Early Pregnancy					**p<0.001**
Mean (SD)	28.9 (8.9)	31.0 (10.2)	41.0 (13.1)	34.2 (11.0)	
Anxiety, Mid Pregnancy					**p<0.001**
Mean (SD)	28.0 (8.9)	33.4 (10.0)	41.6 (13.1)	35.9 (10.0)	
Anxiety, Late Pregnancy					**p<0.001**
Mean (SD)	32.2 (6.3)	37.8 (7.5)	51.5 (8.7)	43.2 (7.4)	
Gestational Age at Delivery (weeks)					p=0.443
Mean (SD)	39.7 (1.1)	39.6 (1.1)	39.6 (1.2)	39.6 (1.6)	
Total Activity, Early Pregnancy (MET hrs)					p=0.519
Mean (SD)	179.7 (111.0)	197.6 (173.7)	196.1 (141.9)	186.0 (133.6)	
Total Activity, Mid Pregnancy (MET hrs)					p=0.062
Mean (SD)	151.7 (87.8)	186.8 (122.2)	182.2 (145.6)	191.2 (135.8)	
Total Activity, Late Pregnancy (MET hrs)					p=0.596
Mean (SD)	152.2 (102.1)	167.0 (91.5)	165.3 (92.8)	164.8 (96.7)	
Medical History					
Pre-Pregnancy BMI					p=0.407
<18.5	4.3%	6.6%	2.0%	6.0%	
18.5-<25	45.1%	45.6%	52.5%	48.9%	
25-<30	25.7%	24.7%	20.8%	20.9%	
≥30	24.9%	23.1%	24.8%	24.2%	
Gravidity					p=0.829
1 total pregnancies	32.3%	33.0%	34.8%	33.0%	
2 total pregnancies	23.5%	23.1%	27.8%	24.2%	
3+ total pregnancies	44.2%	44.0%	37.4%	42.9%	
Parity					p=0.357
0 live births	42.2%	45.1%	45.2%	39.9%	
1 live birth	30.7%	27.5%	34.2%	29.0%	
≥2 live births	27.1%	27.5%	20.6%	31.1%	

Table 1.6b. Distribution of Covariates According to Stress, Mid-Pregnancy: Proyecto Buena Salud, 2006-2010.

	Stress, Mid Pregnancy				
	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	p-value
Demographics					
Age					p=0.395
16-19	25.9%	32.0%	33.1%	35.5%	
20-24	37.3%	42.0%	40.9%	39.0%	
25-29	22.3%	15.4%	16.0%	15.1%	
≥30	14.5%	10.7%	9.9%	10.5%	
Marital Status					p=0.753
Single/Separated/Divorced/Widowed	87.4%	84.8%	87.6%	86.2%	
Married	11.5%	12.2%	10.0%	10.1%	
Refused	1.1%	3.0%	2.4%	3.8%	
Education					p=0.097
less than high school	44.6%	44.8%	51.2%	55.3%	
high school graduate or GED	33.7%	32.1%	32.6%	33.3%	
post high school	21.7%	23.0%	16.3%	11.3%	
Income					**p=0.002**
≤$15,000	24.0%	34.5%	31.8%	42.4%	
>$15,000-$30,000	19.7%	16.4%	13.5%	8.2%	
≥$30,000	10.9%	5.5%	4.1%	3.2%	
don't know/refuse	45.4%	43.6%	50.6%	46.2%	
Number of Adults in Household					**p=0.009**
1	32.1%	21.3%	27.6%	22.6%	
2	46.7%	54.3%	45.3%	40.3%	
≥3	21.2%	24.4%	27.1%	37.1%	
Number of Children in Household					p=0.601
0	21.2%	16.6%	19.3%	22.2%	
1	33.0%	36.8%	33.1%	31.6%	
2	30.2%	29.4%	27.1%	22.8%	
≥3	15.6%	17.2%	20.5%	23.4%	
Acculturation					**p=0.002**
low (1-<3)	70.4%	85.1%	83.9%	80.5%	
high (≥3)	29.6%	14.9%	16.1%	19.5%	
Generation in US					p=0.122
born in PR/DR	46.6%	50.3%	46.3%	43.1%	
parent born in PR/DR	42.9%	46.6%	47.4%	51.5%	
grandparent born in PR/DR	10.6%	3.1%	6.3%	5.4%	
Characteristics of Pregnancy					
Morning Sickness, Early Pregnancy					p=0.268
no	36.9%	33.1%	27.6%	30.2%	
yes	63.1%	66.9%	72.4%	69.8%	
Smoking, Early Pregnancy					p=0.493
None	88.9%	89.3%	85.2%	82.8%	
≤10 cigs/day	10.3%	9.8%	13.9%	13.1%	
>10 cigs/day	0.8%	0.9%	0.9%	4.0%	
Alcohol Consumption, Early Pregnancy					p=0.672
no	98.4%	98.2%	96.5%	99.0%	
yes	1.6%	1.8%	3.5%	1.0%	
Probable Major Depression, Early Pregnancy					**p<0.001**
no	92.8%	91.1%	80.5%	57.9%	
yes	7.2%	8.9%	19.5%	42.1%	

Table 1.6b., continued.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	p-value
Probable Major Depression, Mid Pregnancy					**p<0.001**
no	99.5%	97.6%	78.2%	45.8%	
yes	0.5%	2.4%	21.8%	54.2%	
Probable Major Depression, Late Pregnancy					**p<0.001**
no	95.0%	94.6%	87.1%	69.0%	
yes	5.0%	5.4%	12.9%	31.0%	
Anxiety, Early Pregnancy					**p<0.001**
Mean (SD)	34.1 (8.6)	38.3 (8.7)	48.9 (10.0)	43.4 (7.9)	
Anxiety, Mid Pregnancy					**p<0.001**
Mean (SD)	25.8 (5.8)	30.5 (7.6)	44.1 (12.2)	38.2 (10.4)	
Anxiety, Late Pregnancy					**p<0.001**
Mean (SD)	27.2 (8.8)	31.1 (9.5)	40.0 (12.0)	34.6 (9.9)	
Gestational Age at Delivery (weeks)					p=0.687
Mean (SD)	39.7 (1.1)	39.6 (1.1)	39.5 (1.2)	39.6 (1.2)	
Total Activity, Early Pregnancy (MET hrs)					p=0.956
Mean (SD)	195.9 (118.2)	190.4 (156.7)	199.0 (159.7)	200.8 (149.8)	
Total Activity, Mid Pregnancy (MET hrs)					p=0.683
Mean (SD)	178.1 (126.8)	175.8 (109.3)	191.1 (124.0)	184.6 (133.9)	
Total Activity, Late Pregnancy (MET hrs)					p=0.335
Mean (SD)	151.1 (81.2)	155.1 (102.7)	177.7 (103.7)	163.4 (112.2)	
Medical History					
Pre-Pregnancy BMI					p=0.693
<18.5	5.2%	7.2%	9.6%	5.3%	
18.5-<25	48.2%	40.1%	46.1%	47.3%	
25-<30	20.9%	25.1%	18.5%	21.3%	
≥30	25.7%	27.5%	25.8%	26.0%	
Gravidity					p=0.716
1 total pregnancies	32.6%	33.5%	30.3%	35.1%	
2 total pregnancies	24.2%	28.1%	22.3%	23.8%	
3+ total pregnancies	43.2%	38.3%	47.4%	41.1%	
Parity					p=0.810
0 live births	39.5%	44.9%	42.0%	43.2%	
1 live birth	28.9%	29.9%	26.1%	29.0%	
≥2 live births	31.6%	25.1%	31.8%	27.8%	

Table 1.6c. Distribution of Covariates According to Stress, Late Pregnancy: Proyecto Buena Salud, 2006-2010.

	Stress, Late Pregnancy				
	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	p-value
Demographics					
Age					p=0.268
16-19	26.5%	27.7%	37.2%	31.1%	
20-24	41.2%	44.6%	36.7%	42.4%	
25-29	18.5%	18.2%	15.8%	19.9%	
≥30	13.7%	9.5%	10.2%	6.6%	
Marital Status					p=0.500
Single/Separated/Divorced/Widowed	85.3%	87.6%	85.4%	91.7%	
Married	12.2%	10.9%	10.9%	6.2%	
Refused	2.5%	1.5%	3.6%	2.1%	
Education					p=0.254
less than high school	42.8%	49.3%	46.9%	54.1%	
high school graduate or GED	34.8%	30.7%	32.3%	33.6%	
post high school	22.4%	20.0%	20.8%	12.3%	
Income					p=0.133
≤$15,000	30.5%	28.5%	27.9%	39.7%	
>$15,000-$30,000	18.8%	19.7%	15.3%	8.9%	
≥$30,000	8.1%	6.6%	5.8%	6.2%	
don't know/refuse	42.6%	45.3%	51.1%	45.2%	
Number of Adults in Household					p=0.736
1	30.0%	28.5%	23.4%	25.5%	
2	46.5%	47.4%	51.0%	45.5%	
≥3	23.5%	24.1%	25.5%	29.0%	
Number of Children in Household					p=0.687
0	19.6%	19.4%	14.3%	19.3%	
1	35.1%	41.0%	37.6%	37.9%	
2	26.8%	25.4%	24.9%	24.1%	
≥3	18.6%	14.2%	23.3%	18.6%	
Acculturation					p=0.480
low (1-<3)	75.0%	78.4%	78.8%	82.1%	
high (≥3)	25.0%	21.6%	21.2%	17.9%	
Generation in US					p=0.866
born in PR/DR	46.6%	50.0%	44.7%	45.5%	
parent born in PR/DR	48.5%	43.9%	50.0%	51.0%	
grandparent born in PR/DR	4.9%	6.1%	5.3%	3.5%	
Characteristics of Pregnancy					
Morning Sickness, Early Pregnancy					p=0.128
no	36.0%	38.3%	33.0%	26.0%	
yes	64.0%	61.7%	67.0%	74.0%	
Smoking, Early Pregnancy					p=0.210
None	92.3%	89.3%	85.0%	84.7%	
≤10 cigs/day	7.7%	10.7%	13.5%	12.6%	
>10 cigs/day	0.0%	0.0%	1.5%	2.7%	
Alcohol Consumption, Early Pregnancy					p=0.056
no	97.9%	100.0%	94.6%	99.1%	
yes	2.1%	0.0%	5.4%	0.9%	
Probable Major Depression, Early Pregnancy					**p<0.001**
no	92.8%	89.3%	84.4%	62.0%	
yes	7.2%	10.7%	15.6%	38.0%	

Table 1.6c., continued.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	p-value
Probable Major Depression, Mid Pregnancy					**p<0.001**
no	95.4%	94.2%	81.3%	57.5%	
yes	4.6%	5.8%	18.8%	42.5%	
Probable Major Depression, Late Pregnancy					**p<0.001**
no	99.0%	99.3%	88.6%	55.3%	
yes	1.0%	0.7%	11.4%	44.7%	
Anxiety, Early Pregnancy					**p<0.001**
Mean (SD)	33.9 (8.5)	37.6 (8.2)	47.7 (9.5)	41.1 (8.3)	
Anxiety, Mid Pregnancy					**p<0.001**
Mean (SD)	27.6 (8.0)	32.3 (11.9)	41.1 (12.3)	35.7 (9.3)	
Anxiety, Late Pregnancy					**p<0.001**
Mean (SD)	25.7 (6.0)	29.7 (7.7)	43.4 (12.0)	34.8 (9.8)	
Gestational Age at Delivery (weeks)					p=0.811
Mean (SD)	39.7 (1.2)	39.7 (1.1)	39.6 (1.2)	39.7 (1.2)	
Total Activity, Early Pregnancy (MET hrs)					**p=0.032**
Mean (SD)	169.1 (99.0)	182.1 (103.9)	214.4 (137.5)	187.7 (123.6)	
Total Activity, Mid Pregnancy (MET hrs)					p=0.077
Mean (SD)	174.1 (106.5)	185.5 (133.7)	215.7 (151.1)	170.6 (104.0)	
Total Activity, Late Pregnancy (MET hrs)					**p=0.014**
Mean (SD)	157.6 (87.1)	158.7 (89.3)	187.8 (123.8)	156.7 (89.8)	
Medical History					
Pre-Pregnancy BMI					p=0.540
<18.5	9.5%	3.4%	5.6%	6.0%	
18.5-<25	43.3%	46.2%	48.5%	52.0%	
25-<30	22.4%	22.8%	20.4%	18.7%	
≥30	24.8%	27.6%	25.5%	23.3%	
Gravidity					p=0.838
1 total pregnancies	31.9%	31.3%	34.9%	29.3%	
2 total pregnancies	22.9%	27.8%	24.1%	27.9%	
3+ total pregnancies	45.2%	41.0%	41.0%	42.9%	
Parity					p=0.810
0 live births	39.0%	42.8%	42.1%	36.7%	
1 live birth	35.7%	31.7%	30.3%	32.7%	
≥2 live births	25.2%	25.5%	27.7%	30.6%	

Table 1.7a. Distribution of Covariates According to GWG (Rate GWG): Proyecto Buena Salud, 2006-2010.

	Rate of GWG (lbs/week)			Rate of Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Demographics							
Age			**p<0.001**				p=0.082
16-19	1.16	(0.46)		23.5%	31.8%	34.1%	
20-24	1.00	(0.43)		42.2%	41.4%	36.1%	
25-29	0.97	(0.51)		18.2%	18.5%	17.8%	
≥30	0.92	(0.46)		16.0%	8.3%	12.1%	
Marital Status			**p=0.039**				p=0.436
Single/Separated/Divorced/Widowed	1.05	(0.46)		84.0%	87.4%	89.1%	
Married	0.91	(0.47)		13.7%	9.8%	9.3%	
Refused	1.01	(0.48)		2.3%	2.8%	1.7%	
Education			p=0.831				p=0.082
less than high school	1.03	(0.50)		54.9%	48.3%	43.8%	
high school graduate or GED	1.03	(0.44)		30.9%	35.7%	35.2%	
post high school	1.05	(0.42)		14.3%	16.1%	21.1%	
Income			p=0.140				p=0.140
≤$15,000	0.99	(0.45)		39.3%	25.4%	29.8%	
>$15,000-$30,000	1.01	(0.45)		14.5%	15.5%	17.6%	
≥$30,000	1.03	(0.49)		4.6%	5.6%	6.5%	
don't know/refuse	1.07	(0.47)		41.6%	53.5%	46.1%	
Number of Adults in Household			**p=0.043**				p=0.247
1	1.04	(0.50)		25.1%	19.9%	27.8%	
2	1.00	(0.46)		53.7%	53.2%	47.4%	
≥3	1.10	(0.42)		21.1%	27.0%	24.8%	
Number of Children in Household			**p=0.001**				p=0.069
0	1.15	(0.47)		15.6%	14.4%	21.3%	
1	1.02	(0.45)		41.6%	35.3%	38.5%	
2	1.01	(0.45)		20.8%	25.9%	24.3%	
≥3	0.95	(0.48)		22.0%	24.5%	15.8%	
Acculturation			p=0.438				p=0.785
low (1-<3)	1.03	(0.46)		78.6%	80.8%	78.0%	
high (≥3)	1.06	(0.48)		21.4%	19.2%	22.0%	
Generation in US			**p=0.002**				p=0.745
born in PR/DR	0.99	(0.43)		48.3%	48.4%	46.5%	
parent born in PR/DR	1.06	(0.48)		47.7%	44.4%	47.6%	
grandparent born in PR/DR	1.20	(0.53)		4.0%	7.2%	5.9%	
Characteristics of Pregnancy							
Morning Sickness, Early Pregnancy			**p=0.022**				**p=0.043**
no	1.09	(0.47)		24.6%	37.5%	30.1%	
yes	1.01	(0.46)		75.4%	62.5%	69.9%	
Smoking, Early Pregnancy			**p=0.011**				p=0.164
None	1.06	(0.45)		81.7%	88.6%	88.1%	
≤10 cigs/day	0.91	(0.51)		15.1%	10.5%	11.2%	
>10 cigs/day	0.77	(0.27)		3.2%	1.0%	0.7%	
Alcohol Consumption, Early Pregnancy			**p=0.047**				p=0.232
no	1.03	(0.45)		100.0%	99.0%	97.8%	
yes	1.32	(0.59)		0.0%	1.0%	2.2%	
Probable Major Depression, Early Pregnancy			p=0.596				p=0.382
no	1.04	(0.47)		77.4%	81.6%	83.0%	
yes	1.01	(0.40)		22.6%	18.4%	17.0%	

Table 1.7a., continued.

	Rate of GWG (lbs/week)			Rate of Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Probable Major Depression, Mid Pregnancy			p=0.130				p=0.312
no	1.03	(0.48)		76.4%	83.7%	82.4%	
yes	0.95	(0.45)		23.6%	16.3%	17.6%	
Probable Major Depression, Late Pregnancy			p=0.353				p=0.370
no	1.03	(0.44)		83.5%	85.7%	88.4%	
yes	0.98	(0.44)		16.5%	14.3%	11.6%	
Gestational Age at Delivery (weeks)			**p=0.001**				**p=0.005**
Mean (SD)	39.7	(1.1)		39.5 (1.0)	39.7 (1.1)	39.6 (1.2)	
Total Activity, Early Pregnancy (MET hrs)			p=0.405				p=0.177
Mean (SD)	184.2	(137.3)		166.5 (112.2)	191.9 (149.0)	176.8 (115.4)	
Total Activity, Mid Pregnancy (MET hrs)			p=0.415				p=0.712
Mean (SD)	183.9	(127.1)		189.4 (128.1)	179.5 (114.9)	189.0 (163.9)	
Total Activity, Late Pregnancy (MET hrs)			p=0.501				p=0.911
Mean (SD)	168.9	(102.4)		171.8 (117.4)	167.6 (99.2)	171.3 (94.3)	
Medical History							
Pre-Pregnancy BMI			**p<0.001**				**p<0.001**
<18.5	1.08	(0.32)		11.2%	9.6%	1.8%	
18.5-<25	1.16	(0.42)		44.4%	56.7%	44.6%	
25-<30	1.03	(0.44)		12.3%	17.8%	28.2%	
≥30	0.80	(0.50)		32.1%	15.9%	25.3%	
Gravidity			**p<0.001**				**p=0.003**
1 total pregnancies	1.17	(0.46)		21.4%	35.7%	36.3%	
2 total pregnancies	1.01	(0.47)		28.3%	20.4%	24.2%	
3+ total pregnancies	0.93	(0.45)		50.3%	43.9%	39.5%	
Parity			**p<0.001**				**p<0.001**
0 live births	1.17	(0.46)		26.7%	40.8%	47.2%	
1 live birth	0.98	(0.45)		41.2%	25.5%	30.2%	
≥2 live births	0.88	(0.43)		32.1%	33.8%	22.6%	

Table 1.7b. Distribution of Covariates According to GWG (Total GWG): Proyecto Buena Salud, 2006-2010.

	Total GWG (lbs)			Total Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Demographics							
Age			**p=0.015**				p=0.381
16-19	33.1	(15.4)		29.7%	27.8%	32.2%	
20-24	29.6	(16.2)		44.4%	41.7%	37.9%	
25-29	30.4	(17.6)		15.9%	19.8%	17.1%	
≥30	30.0	(15.8)		9.9%	10.7%	12.8%	
Marital Status			p=0.337				p=0.423
Single/Separated/Divorced/Widowed	31.1	(16.5)		86.9%	87.6%	87.8%	
Married	28.7	(15.3)		9.9%	11.4%	9.8%	
Refused	31.4	(13.8)		3.3%	1.0%	2.4%	
Education			p=0.173				**p=0.002**
less than high school	30.0	(17.0)		58.7%	47.8%	43.8%	
high school graduate or GED	31.4	(16.4)		29.6%	33.2%	34.2%	
post high school	32.2	(14.3)		11.7%	18.9%	22.0%	
Income			**p=0.026**				p=0.133
≤$15,000	29.0	(15.9)		33.2%	32.8%	28.5%	
>$15,000-$30,000	31.5	(14.8)		9.5%	16.6%	17.4%	
≥$30,000	35.0	(19.3)		5.7%	6.4%	6.7%	
don't know/refuse	31.4	(16.6)		51.7%	44.3%	47.4%	
Number of Adults in Household			p=0.303				p=0.498
1	30.9	(16.7)		26.3%	26.4%	27.5%	
2	30.3	(15.8)		46.9%	51.9%	46.2%	
≥3	32.1	(16.8)		26.8%	21.7%	26.3%	
Number of Children in Household			**p=0.001**				p=0.124
0	34.5	(18.8)		15.3%	17.4%	21.4%	
1	30.7	(15.5)		38.8%	33.4%	38.3%	
2	29.5	(15.9)		25.8%	25.6%	23.5%	
≥3	28.6	(15.3)		20.1%	23.5%	16.8%	
Acculturation			p=0.573				p=0.297
low (1-<3)	30.7	(16.3)		81.6%	76.0%	79.3%	
high (≥3)	31.4	(17.0)		18.4%	24.0%	20.7%	
Generation in US			**p=0.001**				**p=0.024**
born in PR/DR	29.4	(15.4)		50.7%	51.2%	42.2%	
parent born in PR/DR	31.7	(17.0)		45.3%	44.2%	50.3%	
grandparent born in PR/DR	36.6	(15.3)		4.0%	4.6%	7.4%	
Characteristics of Pregnancy							
Morning Sickness, Early Pregnancy			**p=0.008**				**p=0.027**
no	32.8	(16.2)		24.4%	34.4%	33.8%	
yes	30.0	(16.3)		75.6%	65.6%	66.2%	
Smoking, Early Pregnancy			**p=0.049**				p=0.426
None	31.7	(15.9)		86.3%	83.9%	87.9%	
≤10 cigs/day	28.5	(17.4)		11.1%	14.6%	11.1%	
>10 cigs/day	22.8	(27.5)		2.6%	1.5%	1.0%	
Alcohol Consumption, Early Pregnancy			**p=0.031**				p=0.069
no	31.0	(16.0)		100.0%	97.6%	97.0%	
yes	39.5	(20.9)		0.0%	2.4%	3.0%	
Probable Major Depression, Early Pregnancy			p=0.253				p=0.073
no	31.4	(16.1)		77.2%	78.3%	84.4%	
yes	29.7	(16.6)		22.8%	21.7%	15.6%	

Table 1.7b., continued.

	Total GWG (lbs)			Total Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Probable Major Depression, Mid Pregnancy			p=0.318				p=0.691
no	30.7	(16.9)		78.9%	82.6%	82.0%	
yes	29.0	(15.8)		21.1%	17.4%	18.0%	
Probable Major Depression, Late Pregnancy			p=0.394				p=0.810
no	31.0	(15.4)		85.0%	87.3%	87.1%	
yes	29.6	(14.5)		15.0%	12.7%	12.9%	
Gestational Age at Delivery (weeks)			**p<0.001**				**p<0.001**
Mean (SD)	39.6	(1.2)		39.3 (1.1)	39.7 (1.2)	39.5 (1.4)	
Total Activity, Early Pregnancy (MET hrs)			p=0.450				p=0.476
Mean (SD)	187.8	(138.4)		177.6 (160.2)	193.5 (136.0)	185.5 (125.2)	
Total Activity, Mid Pregnancy (MET hrs)			p=0.558				p=0.936
Mean (SD)	183.7	(128.3)		187.5 (154.2)	183.2 (117.4)	182.6 (127.2)	
Total Activity, Late Pregnancy (MET hrs)			p=0.171				p=0.695
Mean (SD)	165.0	(98.7)		164.5 (107.5)	163.3 (92.7)	170.9 (104.7)	
Medical History							
Pre-Pregnancy BMI			**p<0.001**				**p<0.001**
<18.5	22.7	(13.5)		9.1%	9.8%	0.0%	
18.5-<25	35.6	(14.3)		49.1%	51.8%	43.0%	
25-<30	31.8	(15.6)		13.8%	18.3%	30.0%	
≥30	23.1	(17.0)		28.0%	20.1%	27.0%	
Gravidity			**p<0.001**				p=0.172
1 total pregnancies	33.9	(16.2)		29.4%	29.6%	35.3%	
2 total pregnancies	30.5	(16.0)		24.7%	24.0%	25.4%	
3+ total pregnancies	29.0	(15.9)		45.9%	46.4%	39.4%	
Parity			**p<0.001**				p=0.065
0 live births	34.0	(16.4)		35.3%	38.8%	45.1%	
1 live birth	29.5	(15.7)		33.6%	30.5%	29.8%	
≥2 live births	27.8	(15.9)		31.0%	30.8%	25.2%	

Table 1.8a. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Stress and Rate GWG: Proyecto Buena Salud, 2006-2010.

	Rate of GWG (lbs/week)								
	Unadjusted			Adjusted for age, pre-pregnancy BMI, total activity and depression in that stage of pregnancy and gravidity			Adjusted for age, pre-pregnancy BMI, total activity, **anxiety** and depression in that stage of pregnancy and gravidity		
	β	(SE)	p-value	β	(SE)	p-value	β	(SE)	p-value
Stress (early pregnancy)	-0.002	(0.003)	p=0.432	-0.004	(0.003)	p=0.161	0.000	(0.004)	p=0.942
Stress (early pregnancy)			p trend = 0.277			p trend = 0.138			p trend = 0.886
1st quartile	Referent	-	-	Referent	-		Referent	-	
2nd quartile	0.013	(0.050)	p=0.792	-0.010	(0.050)	p=0.847	0.022	(0.052)	p=0.673
3rd quartile	0.018	(0.049)	p=0.718	0.128	(0.050)	p=0.797	0.257	(0.056)	p=0.306
4th quartile	-0.066	(0.051)	p=0.194	-0.114	(0.058)	p=0.051	-0.045	(0.072)	p=0.534
Stress (mid-pregnancy)	-0.002	(0.003)	p=0.501	-0.003	(0.003)	p=0.356	-0.004	(0.004)	p=0.374
Stress (mid-pregnancy)			p trend = 0.537			p trend = 0.481			p trend = 0.471
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-0.034	(0.059)	p=0.571	-0.053	(0.059)	p=0.367	-0.030	(0.065)	p=0.649
3rd quartile	-0.006	(0.058)	p=0.924	-0.059	(0.059)	p=0.315	-0.042	(0.070)	p=0.544
4th quartile	-0.045	(0.058)	p=0.439	-0.037	(0.067)	p=0.580	-0.055	(0.080)	p=0.495
Stress (late pregnancy)	-0.003	(0.002)	p=0.220	-0.004[f]	(0.003)	p=0.079	-0.003	(0.003)	p=0.377
Stress (late pregnancy)			p trend = 0.058			**p trend = 0.010**			p trend = 0.063
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-0.068	(0.055)	p=0.216	-0.098	(0.053)	p=0.065	-0.094	(0.054)	p=0.087
3rd quartile	-0.055	(0.050)	p=0.270	-0.069	(0.047)	p=0.148	-0.058	(0.051)	p=0.256
4th quartile	**-0.106**	**(0.053)**	**p=0.044**	**-0.155**	**(0.056)**	**p=0.006**	**-0.131**	**(0.063)**	**p=0.037**

Table 1.8b. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Stress and Adherence to IOM Guidelines for Rate GWG: Proyecto Buena Salud, 2006-2010.

	IOM guidelines, Rate Gestational Weight Gain				IOM guidelines, Rate Gestational Weight Gain				IOM guidelines, Rate Gestational Weight Gain			
	Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG	
	Unadjusted				Adjusted for age, pre-pregnancy BMI, total activity and depression in that phase of pregnancy, and gravidity				Adjusted for age, pre-pregnancy BMI, total activity, **anxiety** and depression in that phase of pregnancy, and gravidity			
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Stress (early pregnancy)	1.00	(0.96-1.03)	0.98	(0.95-1.01)	0.99	(0.94-1.03)	0.97	(0.93-1.01)	0.96	(0.90-1.02)	0.96	(0.91-1.01)
Stress (early pregnancy)		p trend = 0.922		p trend = 0.198		p trend = 0.599		p trend = 0.122		p trend = 0.200		p trend = 0.188
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	1.10	(0.52-2.34)	0.99	(0.53-1.84)	0.75	(0.32-1.73)	0.79	(0.39-1.60)	0.90	(0.38-2.16)	0.81	(0.39-1.67)
3rd quartile	1.26	(0.62-2.59)	1.24	(0.69-2.23)	1.49	(0.68-3.29)	1.41	(0.75-2.67)	1.96	(0.81-4.77)	1.46	(0.72-2.98)
4th quartile	0.99	(0.49-2.02)	1.45	(0.79-2.66)	1.09	(0.46-2.62)	1.70	(0.81-3.55)	1.81	(0.60-5.45)	1.77	(0.71-4.44)
Stress (mid-pregnancy)	1.01	(0.97-1.05)	0.98	(0.95-1.02)	1.00	(0.95-1.05)	0.97	(0.93-1.01)	0.98	(0.93-1.05)	0.96	(0.91-1.01)
Stress (mid-pregnancy)		p trend = 0.738		p trend = 0.398		p trend = 0.720		p trend = 0.096		p trend = 0.652		p trend = 0.193
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	0.96	(0.42-2.18)	1.04	(0.52-2.08)	1.05	(0.43-2.51)	1.37	(0.65-2.88)	1.33	(0.49-3.59)	1.28	(0.57-2.86)
3rd quartile	1.33	(0.60-2.92)	1.39	(0.73-2.65)	1.36	(0.57-3.24)	1.62	(0.79-3.34)	1.74	(0.61-4.96)	1.67	(0.73-3.83)
4th quartile	0.80	(0.36-1.75)	1.24	(0.63-2.45)	1.02	(0.42-2.90)	1.95	(0.85-4.48)	1.20	(0.36-3.92)	1.82	(0.67-4.98)
Stress (late pregnancy)	1.01	(0.97-1.04)	0.99	(0.96-1.02)	1.01	(0.97-1.05)	0.99	(0.96-1.03)	1.00	(0.95-1.05)	0.99	(0.95-1.03)
Stress (late pregnancy)		p trend = 0.379		p trend = 0.304		p trend = 0.372		p trend = 0.407		p trend = 0.666		p trend = 0.395
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	0.90	(0.38-2.12)	0.85	(0.42-1.72)	0.90	(0.36-2.23)	0.96	(0.45-2.05)	0.97	(0.38-2.46)	1.00	(0.46-2.17)
3rd quartile	1.37	(0.66-2.86)	1.45	(0.80-2.63)	1.36	(063-2.92)	1.55	(0.83-2.89)	1.47	(0.65-3.32)	1.57	(0.80-3.06)
4th quartile	0.65	(0.30-1.39)	1.23	(0.63-2.39)	0.56	(0.23-1.37)	1.18	(0.54-2.57)	0.68	(0.25-1.85)	1.25	(0.53-1.85)

Table 1.9a. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Stress and Total GWG: Proyecto Buena Salud, 2006-2010.

	Total GWG (lbs)								
	Unadjusted			Adjusted for age, pre-pregnancy BMI, total activity and depression in that stage and gravidity			Adjusted for age, pre-pregnancy BMI, total activity, **anxiety** and depression in that stage and gravidity		
	β	(SE)	p-value	β	(SE)	p-value	β	(SE)	p-value
Stress (early pregnancy)	-0.16	(0.08)	p=0.053	-0.18[a]	(0.09)	p=0.054	-0.03[b]	(0.12)	p=0.821
Stress (early pregnancy)			**p trend = 0.034**			p trend = 0.057			p trend = 0.712
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-1.05	(1.64)	p=0.522	-1.36[a]	(1.65)	p=0.410	-0.17[b]	(1.71)	p=0.921
3rd quartile	-1.31	(1.59)	p=0.409	-0.79[a]	(1.62)	p=0.627	-0.90[b]	(1.81)	p=0.619
4th quartile	**-3.54**	**(1.62)**	**p=0.029**	**-4.00[a]**	**(1.85)**	**p=0.031**	-1.48[b]	(2.28)	p=0.515
Stress (mid-pregnancy)	-0.11	(0.09)	p=0.235	-0.07[c]	(0.10)	p=0.497	-0.14[d]	(0.13)	p=0.292
Stress (mid-pregnancy)			p trend = 0.111			p trend = 0.295			p trend = 0.272
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-2.68	(1.80)	p=0.138	-3.47[c]	(1.80)	p=0.055	-3.21[d]	(2.02)	p=0.112
3rd quartile	-2.91	(1.79)	p=0.105	**-3.65[c]**	**(1.85)**	**p=0.049**	-4.21[d]	(2.18)	p=0.055
4th quartile	-2.84	(1.81)	p=0.117	-1.56[c]	(2.08)	p=0.454	1.94[d]	(2.55)	p=0.448
Stress (late pregnancy)	-0.12	(0.08)	p=0.132	-0.12[e]	(0.09)	p=0.148	-0.08[f]	(0.10)	p=0.407
Stress (late pregnancy)			p trend = 0.098			p trend = 0.112			p trend = 0.263
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-1.19	(1.69)	p=0.479	-1.85[e]	(1.72)	p=0.283	-1.27f	(1.75)	p=0.468
3rd quartile	-1.27	(1.55)	p=0.414	-1.02[e]	(1.55)	p=0.511	-0.70[f]	(1.65)	p=0.670
4th quartile	-2.85	(1.67)	p=0.087	-3.43[e]	(1.90)	p=0.072	-2.71[f]	(2.10)	p=0.197

Table 1.9b. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Stress and Adherence to IOM Guidelines for Total GWG: Proyecto Buena Salud, 2006-2010.

	IOM guidelines, Total Gestational Weight Gain				IOM guidelines, Total Gestational Weight Gain				IOM guidelines, Total Gestational Weight Gain			
	Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG	
	Unadjusted				Adjusted for age, pre-pregnancy BMI, total activity and depression in that phase of pregnancy, and gravidity				Adjusted for age, pre-pregnancy BMI, total activity, **anxiety** and depression in that phase of pregnancy, and gravidity			
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Stress (early pregnancy)	1.01	(0.98-1.04)	0.98	(0.96-1.00)	1.02	(0.98-1.06)	0.99	(0.96-1.02)	1.00	(0.96-1.05)	0.99	(0.95-1.03)
Stress (early pregnancy)	p trend = 0.236		p trend = 0.239		p trend = 0.163		p trend = 0.735		p trend = 0.559		p trend = 0.992	
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	1.28	(0.69-2.39)	1.13	(0.70-1.81)	1.26	(0.66-2.44)	1.24	(0.75-2.05)	1.37	(0.69-2.72)	1.16	(0.69-2.72)
3rd quartile	0.99	(0.55-1.79)	1.04	(0.65-1.65)	0.92	(0.49-1.76)	0.93	(0.56-1.54)	1.04	(0.51-2.13)	0.87	(0.50-1.54)
4th quartile	0.74	(0.42-1.30)	1.39	(0.87-2.24)	0.62	(0.31-1.23)	1.21	(0.68-2.15)	0.77	(0.33-1.82)	1.10	(0.54-2.24)
Stress (mid-pregnancy)	1.01	(0.98-1.04)	0.99	(0.97-1.01)	1.01	(0.97-1.04)	0.99	(0.96-1.02)	1.01	(0.96-1.06)	0.99	(0.95-1.03)
Stress (mid-pregnancy)	p trend = 0.567		p trend = 0.397		p trend = 0.597		p trend = 0.435		p trend = 0.649		p trend = 0.713	
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	0.67	(0.36-1.26)	0.92	(0.55-1.52)	0.66	(0.34-1.29)	1.07	(0.63-1.83)	0.60	(0.28-1.30)	0.91	(0.48-1.70)
3rd quartile	0.83	(0.45-1.56)	1.08	(066-1.76)	0.75	(0.38-1.48)	1.16	(0.68-1.99)	0.75	(0.33-1.71)	1.12	(0.58-2.17)
4th quartile	0.78	(0.42-1.45)	1.21	(0.74-1.98)	0.81	(0.8-1.71)	1.26	(0.69-2.32)	0.81	(0.31-2.10)	1.13	(0.52-2.44)
Stress (late pregnancy)	1.00	(0.97-1.03)	0.99	(0.97-1.01)	1.00	(0.97-1.04)	0.99	(0.97-1.02)	1.01	(0.97-1.05)	1.00	(0.97-1.03)
Stress (late pregnancy)	p trend = 0.431		p trend = 0.459		p trend = 0.324		p trend = 0.606		p trend = 0.173		p trend = 0.941	
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	0.72	(0.37-1.38)	0.88	(0.53-1.46)	0.73	(0.37-1.45)	0.96	(0.56-1.65)	0.68	(0.34-1.37)	0.91	(0.53-1.58)
3rd quartile	0.69	(0.38-1.27)	0.80	(0.50-1.27)	0.72	(0.38-1.36)	0.84	(0.52-1.36)	0.66	(0.33-1.30)	0.79	(0.47-1.33)
4th quartile	0.78	(0.42-1.45)	1.28	(0.79-2.09)	0.71	(0.34-1.47)	1.33	(0.74-2.39)	0.57	(0.25-1.29)	1.15	(0.60-2.22)

Table 1.10. Distribution of Anxiety (Early, Mid and Late Pregnancy): Proyecto Buena Salud, 2006-2010.

	N	Range	M (SD)
Trait Anxiety (early pregnancy)	894	(20-76)	40.2 (10.3)
Trait Anxiety (early pregnancy)			
1st quartile	231	(20-32)	28.0 (3.3)
2nd quartile	222	(33-39)	35.8 (2.0)
3rd quartile	244	(40-48)	43.9 (2.7)
4th quartile	197	(49-76)	54.9 (5.4)
State Anxiety (mid-pregnancy)	533	(20-77)	34.0 (11.5)
State Anxiety (mid-pregnancy)			
1st quartile	155	(20-25)	22.3 (1.8)
2nd quartile	114	(26-31)	28.6 (1.7)
3rd quartile	134	(32-41)	36.1 (3.0)
4th quartile	130	(42-77)	50.7 (7.4)
State Anxiety (late pregnancy)	702	(20-79)	32.9 (11.2)
State Anxiety (late pregnancy)			
1st quartile	205	(20-24)	21.8 (1.4)
2nd quartile	157	(25-30)	27.4 (1.7)
3rd quartile	173	(31-40)	35.1 (3.0)
4th quartile	167	(41-79)	49.4 (7.5)

Table 1.11a. Distribution of Covariates According to Anxiety, Early Pregnancy: Proyecto Buena Salud, 2006-2010.

	Trait Anxiety Early Pregnancy				
	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	
	%	%	%	%	p-value
Demographics					
Age					**p=0.014**
16-19	30.7%	36.5%	33.6%	28.4%	
20-24	33.8%	37.4%	43.0%	42.6%	
25-29	19.0%	16.7%	13.1%	21.8%	
≥30	16.5%	9.5%	10.2%	7.1%	
Marital Status					**p=0.014**
Single/Separated/Divorced/Widowed	85.2%	85.6%	87.4%	94.4%	
Married	13.1%	12.6%	8.8%	4.6%	
Refused	1.7%	1.8%	3.8%	1.0%	
Education					**p<0.001**
less than high school	43.3%	41.9%	46.3%	61.5%	
high school graduate or GED	31.2%	34.2%	33.5%	27.2%	
post high school	25.5%	23.9%	20.2%	11.3%	
Income					**p<0.001**
≤$15,000	25.2%	22.6%	34.2%	39.7%	
>$15,000-$30,000	17.0%	17.6%	11.7%	11.9%	
≥$30,000	10.0%	9.5%	6.7%	2.6%	
don't know/refuse	47.8%	50.2%	47.5%	45.9%	
Number of Adults in Household					p=0.521
1	22.1%	24.1%	14.6%	29.2%	
2	50.2%	48.2%	46.9%	41.0%	
≥3	27.7%	27.7%	25.9%	29.7%	
Number of Children in Household					p=0.394
0	22.5%	16.4%	21.9%	19.3%	
1	30.6%	34.1%	37.6%	36.5%	
2	25.2%	30.9%	21.5%	23.4%	
≥3	21.6%	18.6%	19.0%	20.8%	
Acculturation					p=0.876
low (1-<3)	80.4%	80.1%	77.8%	80.4%	
high (≥3)	19.6%	19.9%	22.2%	19.6%	
Generation in US					p=0.149
born in PR/DR	53.6%	46.0%	40.9%	46.6%	
parent born in PR/DR	42.0%	47.9%	51.9%	49.7%	
grandparent born in PR/DR	4.5%	6.1%	7.2%	3.7%	
Characteristics of Pregnancy					
Morning Sickness, Early Pregnancy					**p=0.001**
no	33.0%	23.0%	21.9%	17.4%	
yes	67.0%	77.0%	78.1%	82.6%	
Smoking, Early Pregnancy					**p<0.001**
None	91.7%	91.2%	86.0%	76.1%	
≤10 cigs/day	7.8%	8.3%	12.7%	20.7%	
>10 cigs/day	0.5%	0.5%	1.3%	3.3%	
Alcohol Consumption, Early Pregnancy					p=0.397
no	97.6%	99.0%	97.0%	96.8%	
yes	2.4%	1.0%	3.0%	3.2%	
Probable Major Depression, Early Pregnancy					**p<0.001**
no	99.0%	98.5%	83.3%	43.7%	
yes	1.0%	1.5%	16.7%	56.3%	

Table 1.11a., continued.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	
	%	%	%	%	p-value
Probable Major Depression, Mid Pregnancy					**p<0.001**
no	97.3%	93.3%	82.1%	53.6%	
yes	2.7%	6.7%	17.9%	46.4%	
Probable Major Depression, Late Pregnancy					**p<0.001**
no	97.7%	94.4%	83.2%	61.8%	
yes	2.3%	5.6%	16.8%	38.2%	
Stress, Early Pregnancy					**p<0.001**
Mean (SD)	19.9 (5.6)	23.9 (5.0)	33.3 (5.6)	27.7 (4.5)	
Stress, Mid Pregnancy					**p<0.001**
Mean (SD)	19.3 (6.6)	23.4 (5.9)	30.7 (6.5)	26.1 (6.1)	
Stress, Late Pregnancy					**p<0.001**
Mean (SD)	19.3 (7.5)	21.8 (6.3)	29.7 (7.7)	25.8 (5.9)	
Gestational Age at Delivery (weeks)					p=0.075
Mean (SD)	39.7 (1.2)	39.7 (1.1)	39.4 (1.2)	39.7 (1.6)	
Total Activity, Early Pregnancy (MET hrs)					p=0.070
Mean (SD)	175.1(135.3)	175.1 (101.5)	200.1 (143.2)	201.3 (155.1)	
Total Activity, Mid Pregnancy (MET hrs)					p=0.079
Mean (SD)	155.1 (96.5)	177.7 (118.8)	198.7 (155.8)	184.5 (118.3)	
Total Activity, Late Pregnancy (MET hrs)					p=0.244
Mean (SD)	155.2 (108.1)	156.0 (82.7)	178.8 (107.7)	165.0 (88.4)	
Medical History					
Pre-Pregnancy BMI					p=0.847
<18.5	3.5%	5.9%	4.7%	5.2%	
18.5-<25	46.0%	50.9%	47.4%	44.3%	
25-<30	23.9%	22.3%	21.8%	25.0%	
≥30	26.5%	20.9%	26.1%	25.5%	
Gravidity					p=0.157
1 total pregnancies	36.2%	36.9%	32.3%	28.0%	
2 total pregnancies	19.2%	25.7%	27.2%	27.0%	
3+ total pregnancies	44.5%	37.4%	40.5%	46.6%	
Parity					p=0.106
0 live births	48.0%	46.3%	43.8%	34.7%	
1 live birth	24.9%	29.0%	31.8%	34.2%	
≥2 live births	27.1%	24.8%	24.5%	31.1%	

Table 1.11b. Distribution of Covariates According to Anxiety, Mid Pregnancy: Proyecto Buena Salud, 2006-2010.

	State Anxiety, Mid Pregnancy				
	1st Quartile %	2nd Quartile %	3rd Quartile %	4th Quartile %	p-value
Demographics					
Age					p=0.553
16-19	30.3%	33.3%	39.6%	28.7%	
20-24	37.4%	43.0%	35.8%	39.5%	
25-29	18.7%	16.7%	14.2%	19.4%	
≥30	13.5%	7.0%	10.4%	12.4%	
Marital Status					p=0.864
Single/Separated/Divorced/Widowed	86.6%	85.7%	88.9%	87.9%	
Married	11.4%	12.4%	10.3%	8.9%	
Refused	2.0%	1.9%	0.8%	3.2%	
Education					p=0.922
less than high school	52.7%	47.2%	46.0%	45.2%	
high school graduate or GED	30.7%	34.3%	35.7%	35.5%	
post high school	16.7%	18.5%	18.3%	19.4%	
Income					**p=0.015**
≤$15,000	27.3%	29.9%	22.4%	45.5%	
>$15,000-$30,000	14.7%	13.1%	20.0%	9.8%	
≥$30,000	6.7%	3.7%	6.4%	5.7%	
don't know/refuse	51.3%	53.3%	51.2%	39.0%	
Number of Adults in Household					p=0.760
1	26.0%	20.6%	27.4%	26.6%	
2	44.7%	48.6%	49.2%	43.5%	
≥3	29.3%	30.8%	23.4%	29.8%	
Number of Children in Household					p=0.513
0	23.1%	16.8%	20.5%	21.3%	
1	29.9%	37.4%	27.9%	38.5%	
2	30.6%	25.2%	31.1%	21.3%	
≥3	16.3%	20.6%	20.5%	18.9%	
Acculturation					p=0.739
low (1-<3)	81.1%	76.4%	80.8%	81.8%	
high (≥3)	18.9%	23.6%	19.2%	18.2%	
Generation in US					p=0.767
born in PR/DR	46.6%	53.6%	46.2%	43.7%	
parent born in PR/DR	47.3%	41.8%	48.5%	48.4%	
grandparent born in PR/DR	6.1%	4.5%	5.4%	7.9%	
Characteristics of Pregnancy					
Morning Sickness, Early Pregnancy					p=0.747
no	27.6%	22.7%	22.7%	24.4%	
yes	72.4%	77.3%	77.3%	75.6%	
Smoking, Early Pregnancy					p=0.567
None	87.2%	91.4%	83.1%	83.6%	
≤10 cigs/day	11.2%	8.6%	14.4%	13.8%	
>10 cigs/day	1.6%	0.0%	2.5%	2.6%	
Alcohol Consumption, Early Pregnancy					p=0.303
no	98.4%	98.9%	99.1%	95.7%	
yes	1.6%	1.1%	0.9%	4.3%	
Probable Major Depression, Early Pregnancy					**p<0.001**
no	89.8%	94.4%	84.3%	61.7%	
yes	10.2%	5.6%	15.7%	38.3%	

Table 1.11b., continued.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	
	%	%	%	%	p-value
Probable Major Depression, Mid Pregnancy					**p<0.001**
no	98.0%	97.4%	83.5%	49.6%	
yes	2.0%	2.6%	16.5%	50.4%	
Probable Major Depression, Late Pregnancy					**p<0.001**
no	95.7%	93.5%	85.7%	71.7%	
yes	4.3%	6.5%	14.3%	28.3%	
Stress, Early Pregnancy					**p<0.001**
Mean (SD)	22.6 (6.4)	25.2 (6.9)	30.8 (6.3)	26.9 (6.4)	
Stress, Mid Pregnancy					**p<0.001**
Mean (SD)	19.1 (6.6)	23.4 (5.8)	31.5 (5.4)	26.1 (5.5)	
Stress, Late Pregnancy					**p<0.001**
Mean (SD)	18.8 (7.4)	21.7 (7.3)	28.6 (7.2)	26.0 (7.7)	
Gestational Age at Delivery (weeks)					p=0.513
Mean (SD)	39.7 (1.1)	39.6 (1.3)	39.5 (1.2)	39.6 (1.1)	
Total Activity, Early Pregnancy (MET hrs)					p=0.072
Mean (SD)	174.8 (102.4)	189.1 (142.0)	196.4 (127.5)	224.3 (194.6)	
Total Activity, Mid Pregnancy (MET hrs)					**p=0.011**
Mean (SD)	152.9 (87.4)	201.9 (163.8)	181.2 (114.2)	190.1 (123.8)	
Total Activity, Late Pregnancy (MET hrs)					p=0.142
Mean (SD)	143.8 (77.8)	148.7 (86.3)	175.8 (112.5)	178.2 (119.3)	
Medical History					
Pre-Pregnancy BMI					P=0.798
<18.5	5.3%	8.8%	3.7%	4.0%	
18.5-<25	42.1%	47.4%	46.3%	48.0%	
25-<30	25.0%	20.2%	24.6%	20.8%	
≥30	27.6%	23.7%	25.4%	27.2%	
Gravidity					p=0.108
1 total pregnancies	34.0%	35.4%	33.1%	29.6%	
2 total pregnancies	22.9%	31.9%	23.8%	18.4%	
3+ total pregnancies	43.1%	32.7%	43.1%	52.0%	
Parity					p=0.884
0 live births	43.8%	45.1%	45.5%	39.2%	
1 live birth	26.8%	27.4%	24.2%	32.0%	
≥2 live births	29.4%	27.4%	30.3%	28.8%	

Table 1.11c. Distribution of Covariates According to Anxiety, Late Pregnancy: Proyecto Buena Salud, 2006-2010.

	State Anxiety Late Pregnancy				
	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	
	%	%	%	%	p-value
Demographics					
Age					p=0.110
16-19	25.4%	38.2%	30.1%	29.9%	
20-24	40.5%	40.8%	44.5%	38.9%	
25-29	21.5%	11.5%	18.5%	19.2%	
≥30	12.7%	9.6%	6.9%	12.0%	
Marital Status					p=0.301
Single/Separated/Divorced/Widowed	85.2%	87.5%	87.5%	89.4%	
Married	13.8%	9.9%	9.5%	6.9%	
Refused	1.1%	2.6%	3.0%	3.8%	
Education					p=0.487
less than high school	44.8%	49.7%	49.7%	48.4%	
high school graduate or GED	32.3%	29.4%	34.3%	36.0%	
post high school	22.9%	20.9%	16.0%	15.5%	
Income					p=0.066
≤$15,000	25.9%	30.3%	35.1%	35.2%	
>$15,000-$30,000	22.2%	15.1%	11.3%	12.6%	
≥$30,000	8.5%	9.2%	5.4%	4.4%	
don't know/refuse	43.4%	45.4%	48.2%	47.8%	
Number of Adults in Household					p=0.219
1	26.2%	21.2%	26.6%	34.2%	
2	50.3%	48.3%	48.5%	43.5%	
≥3	23.6%	30.5%	24.9%	22.4%	
Number of Children in Household					**p=0.028**
0	18.4%	24.2%	13.9%	16.9%	
1	31.9%	37.6%	45.2%	35.0%	
2	30.8%	24.2%	18.1%	28.1%	
≥3	18.9%	14.1%	22.9%	20.0%	
Acculturation					p=0.547
low (1-<3)	80.7%	75.2%	80.4%	76.6%	
high (≥3)	19.3%	24.8%	19.6%	23.4%	
Generation in US					p=0.461
born in PR/DR	49.7%	44.7%	47.0%	45.1%	
parent born in PR/DR	45.2%	53.3%	47.6%	48.2%	
grandparent born in PR/DR	5.1%	2.0%	5.4%	6.7%	
Characteristics of Pregnancy					
Morning Sickness, Early Pregnancy					p=0.376
no	35.6%	35.7%	33.9%	27.8%	
yes	64.4%	64.3%	66.1%	72.2%	
Smoking, Early Pregnancy					p=0.284
None	90.8%	92.5%	85.3%	83.3%	
≤10 cigs/day	8.4%	7.5%	12.9%	15.0%	
>10 cigs/day	0.8%	0.0%	1.7%	1.7%	
Alcohol Consumption, Early Pregnancy					p=0.509
no	98.5%	98.1%	95.6%	98.3%	
yes	1.5%	1.9%	4.4%	1.7%	
Probable Major Depression, Early Pregnancy					**p<0.001**
no	94.5%	87.6%	83.9%	62.4%	
yes	5.5%	12.4%	16.1%	37.6%	

Table 1.11c., continued.

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	
	%	%	%	%	p-value
Probable Major Depression, Mid Pregnancy					**p<0.001**
no	96.2%	94.8%	75.3%	64.4%	
yes	3.8%	5.2%	24.7%	35.6%	
Probable Major Depression, Late Pregnancy					**p<0.001**
no	99.5%	96.8%	90.7%	57.5%	
yes	0.5%	3.2%	9.3%	42.5%	
Stress, Early Pregnancy					**p<0.001**
Mean (SD)	22.2 (6.5)	25.3 (6.8)	30.2 (7.1)	26.9 (6.3)	
Stress, Mid Pregnancy					**p<0.001**
Mean (SD)	21.4 (6.7)	22.7 (6.7)	30.0 (6.5)	26.6 (6.2)	
Stress, Late Pregnancy					**p<0.001**
Mean (SD)	18.4 (6.6)	21.4 (5.9)	30.1 (6.4)	24.9 (6.2)	
Gestational Age at Delivery (weeks)					p=0.650
Mean (SD)	39.7 (1.1)	39.7 (1.1)	39.6 (1.2)	39.6 (1.2)	
Total Activity, Early Pregnancy (MET hrs)					p=0.054
Mean (SD)	177.1 (124.2)	171.6 (96.2)	211.3 (125.9)	184.7 (117.6)	
Total Activity, Mid Pregnancy (MET hrs)					p=0.094
Mean (SD)	190.5 (121.8)	164.7 (111.2)	208.8 (158.9)	170.9 (89.3)	
Total Activity, Late Pregnancy (MET hrs)					**p=0.004**
Mean (SD)	166.7 (90.6)	143.0 (72.5)	181.2 (119.3)	156.2 (94.3)	
Medical History					
Pre-Pregnancy BMI					p=0.870
<18.5	5.9%	5.1%	5.8%	8.4%	.
18.5-<25	44.3%	51.9%	47.7%	47.0%	
25-<30	21.7%	17.9%	22.7%	20.5%	
≥30	28.1%	25.0%	23.8%	24.1%	
Gravidity					p=0.137
1 total pregnancies	29.9%	40.0%	29.4%	28.8%	
2 total pregnancies	22.1%	25.8%	27.6%	25.8%	
3+ total pregnancies	48.0%	34.2%	42.9%	45.4%	
Parity					p=0.157
0 live births	39.7%	49.7%	34.5%	36.8%	
1 live birth	31.9%	31.6%	36.3%	30.7%	
≥2 live births	28.4%	18.7%	29.2%	32.5%	

Table 1.12a. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Anxiety and Rate GWG: Proyecto Buena Salud, 2006-2010.

	Rate of GWG (lbs/week)								
	Unadjusted			Adjusted for age, pre-pregnancy BMI, depression in that stage of pregnancy and gravidity			Adjusted for age, pre-pregnancy BMI, **stress** and depression in that stage of pregnancy and gravidity		
	β	(SE)	p-value	β	(SE)	p-value	β	(SE)	p-value
Trait Anxiety (early pregnancy)	**-0.004**	**(0.002)**	**p=0.036**	**-0.005**	**(0.002)**	**p=0.022**	**-0.006**	**(0.003)**	**p=0.042**
Trait Anxiety (early pregnancy)			p trend = 0.099			p trend = 0.097			p trend = 0.214
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-0.032	(0.049)	p=0.516	-0.059	(0.049)	p=0.222	-0.056	(0.051)	p=0.413
3rd quartile	0.033	(0.049)	p=0.506	-0.003	(0.049)	p=0.944	-0.005	(0.055)	p=0.952
4th quartile	**-0.108**	**(0.050)**	**p=0.031**	**-0.138**	**(0.060)**	**p=0.021**	-0.127	(0.072)	p=0.079
State Anxiety (mid-pregnancy)	-0.001	(0.002)	p=0.589	0.001	(0.002)	p=0.621	0.002	(0.003)	p=0.503
State Anxiety (mid-pregnancy)			p trend = 0.426			p trend = 0.929			p trend = 0.984
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-0.043	(0.065)	p=0.512	-0.067	(0.061)	p=0.272	-0.065	(0.065)	p=0.311
3rd quartile	0.003	(0.062)	p=0.965	-0.016	(0.061)	p=0.793	-0.015	(0.066)	p=0.824
4th quartile	-0.061	(0.063)	p=0.332	-0.017	(0.068)	p=0.801	-0.018	(0.080)	p=0.825
State Anxiety (late pregnancy)	-0.003	(0.002)	p=0.055	-0.004	(0.002)	p=0.055	-0.003	(0.002)	p=0.159
State Anxiety (late pregnancy)			**p trend = 0.032**			**p trend = 0.036**			p trend = 0.102
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	0.049	(0.054)	p=0.361	0.022	(0.050)	p=0.659	0.021	(0.051)	p=0.685
3rd quartile	-0.037	(0.051)	p=0.467	-0.057	(0.048)	p=0.232	-0.050	(0.051)	p=0.330
4th quartile	-0.087	(0.051)	p=0.089	-0.092	(0.053)	p=0.080	-0.081	(0.060)	p=0.172

Table 1.12b. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Anxiety and Adherence to IOM Guidelines for Rate GWG: Proyecto Buena Salud, 2006-2010.

	IOM guidelines, Rate Gestational Weight Gain				IOM guidelines, Rate Gestational Weight Gain				IOM guidelines, Rate Gestational Weight Gain			
	Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG	
	Unadjusted				Adjusted for age, pre-pregnancy BMI, depression in that stage of pregnancy and gravidity				Adjusted for age, pre-pregnancy BMI, **stress** and depression in that stage of pregnancy and gravidity			
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Trait Anxiety (early pregnancy)	1.01	(0.99-1.03)	0.99	(0.97-1.01)	1.01	(0.98-1.05)	0.99	(0.96-1.02)	1.03	(0.99-1.08)	1.00	(0.97-1.04)
Trait Anxiety (early pregnancy)	p trend = 0.262		p trend = 0.505		p trend = 0.262		p trend = 0.761		p trend = 0.095		p trend = 0.623	
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	1.10	(0.54-2.24)	1.28	(0.73-2.25)	0.95	(0.43-2.06)	1.24	(0.67-2.29)	0.84	(0.38-1.87)	1.14	(0.60-2.14)
3rd quartile	0.62	(0.29-1.35)	0.61	(0.32-1.16)	0.49	(0.21-1.16)	0.57	(0.28-1.16)	**0.38**	(**0.15-0.97**)	0.48	(0.22-1.04)
4th quartile	0.78	(0.39-1.56)	1.54	(0.86-2.76)	0.74	(0.30-1.84)	1.65	(0.76-3.55)	0.50	(0.16-1.52)	1.18	(0.47-2.98)
State Anxiety (mid-pregnancy)	1.01	(0.98-1.03)	1.00	(0.98-1.02)	0.99	(0.96-1.03)	1.00	(0.97-1.03)	1.00	(0.96-1.05)	1.01	(0.98-1.05)
State Anxiety (mid-pregnancy)	p trend = 0.953		p trend = 0.588		p trend = 0.636		p trend = 0.437		p trend = 0.997		p trend = 0.995	
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	1.86	(0.76-4.57)	2.02	(0.98-4.17)	1.98	(0.77-5.06)	**2.25**	(**1.06-4.79**)	1.80	(0.68-4.80)	1.98	(0.90-4.36)
3rd quartile	1.21	0.49-3.00)	1.18	(0.56-2.50)	1.31	(0.50-3.42)	1.35	(0.62-2.97)	1.18	(0.43-3.30)	1.20	(0.52-2.77)
4th quartile	1.16	(0.48-2.82)	1.48	(0.70-3.11)	1.49	(0.53-4.25)	1.65	(0.70-3.87)	1.22	(0.36-4.15)	1.25	(0.46-3.42)
State Anxiety (late pregnancy)	1.01	(0.99-1.04)	0.99	(0.97-1.02)	1.02	(0.99-1.05)	1.00	(0.98-1.03)	1.02	(0.99-1.06)	1.00	(0.97-1.03)
State Anxiety (late pregnancy)	p trend = 0.194		p trend = 0.677		p trend = 0.187		p trend = 0.961		p trend = 0.193		p trend = 0.852	
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	1.06	(0.47-2.39)	1.03	(0.53-1.99)	0.94	(0.41-2.15)	1.02	(0.52-1.99)	0.93	(0.40-2.14)	1.00	(0.51-1.98)
3rd quartile	0.84	(0.39-1.80)	1.08	(0.57-2.03)	0.79	(0.36-1.72)	1.03	(0.54-1.97)	0.76	(0.33-1.73)	0.96	(0.49-1.91)
4th quartile	0.65	(0.31-1.37)	1.14	(0.60-2.17)	0.58	(0.25-1.36)	1.02	(0.49-2.10)	0.55	(0.21-1.42)	0.93	(0.42-2.09)

Table 1.13a. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Anxiety and Total GWG: Proyecto Buena Salud, 2006-2010.

	Total GWG (lbs)								
	Unadjusted			Adjusted for age, pre-pregnancy BMI, depression in that stage of pregnancy and gravidity			Adjusted for age, pre-pregnancy BMI, **stress** and depression in that stage of pregnancy and gravidity		
	β	(SE)	p-value	β	(SE)	p-value	β	(SE)	p-value
Trait Anxiety (early pregnancy)	**-0.17**	**(0.05)**	**p=0.002**	**-0.18**	**(0.07)**	**p=0.006**	**-0.19**	**(0.09)**	**p=0.033**
Trait Anxiety (early pregnancy)			**p trend = 0.011**			**p trend = 0.044**			p trend = 0.221
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-1.31	(1.59)	p=0.410	-1.76	(1.60)	p=0.274	-1.39	(1.68)	p=0.408
3rd quartile	-1.44	(1.56)	p=0.358	-1.69	(1.59)	p=0.286	-1.24	(1.81)	p=0.493
4th quartile	**-4.33**	**(1.62)**	**p=0.008**	**-4.22**	**(1.92)**	**p=0.028**	-3.23	(2.33)	p=0.167
State Anxiety (mid-pregnancy)	-0.02	(0.06)	p=0.806	0.07	(0.07)	p=0.332	0.12	(0.09)	p=0.180
State Anxiety (mid-pregnancy)			p trend = 0.837			p trend = 0.486			p trend = 0.302
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	-2.19	(2.11)	p=0.300	-2.55	(1.99)	p=0.201	-2.05	(2.06)	p=0.321
3rd quartile	-1.27	(1.98)	p=0.522	-0.50	(1.91)	p=0.794	0.16	(2.07)	p=0.938
4th quartile	-0.76	(2.03)	p=0.710	1.18	(2.17)	p=0.589	2.09	(2.51)	p=0.406
State Anxiety (late pregnancy)	-0.10	(0.05)	p=0.067	-0.1	(0.06)	p=0.098	-0.09	(0.07)	p=0.200
State Anxiety (late pregnancy)			p trend = 0.084			p trend = 0.159			p trend = 0.348
1st quartile	Referent	-	-	Referent	-	-	Referent	-	-
2nd quartile	0.16	(1.65)	p=0.924	-0.23	(1.59)	p=0.883	-0.12	(1.63)	p=0.940
3rd quartile	-2.82	(1.62)	p=0.081	-2.74	(1.57)	p=0.081	-2.55	(1.68)	p=0.129
4th quartile	-2.16	(1.62)	p=0.181	-1.84	(1.73)	p=0.288	-1.32	(1.95)	p=0.497

Table 1.13b. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Anxiety and Adherence to IOM Guidelines for Total GWG: Proyecto Buena Salud, 2006-2010.

	IOM guidelines, Total Gestational Weight Gain				IOM guidelines, Total Gestational Weight Gain				IOM guidelines, Total Gestational Weight Gain			
	Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG		Inadequate Rate GWG		Excessive Rate GWG	
	Unadjusted				Adjusted for age, pre-pregnancy BMI, depression in that stage of pregnancy and gravidity				Adjusted for age, pre-pregnancy BMI, **stress** and depression in that stage of pregnancy and gravidity			
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Trait Anxiety (early pregnancy)	1.01	(0.99-1.03)	**0.98**	**(0.97-0.99)**	1.02	(0.99-1.04)	0.99	(0.97-1.02)	1.02	(0.99-1.05)	1.00	(0.97-1.03)
Trait Anxiety (early pregnancy)		p trend = 0.516		p trend = 0.166		p trend = 0.235		p trend = 0.942		p trend = 0.303		p trend = 0.515
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	1.17	(0.65-2.11)	1.51	(0.95-2.40)	1.11	(0.59-2.10)	1.46	(0.89-2.39)	1.04	(0.54-2.01)	1.32	(0.79-2.21)
3rd quartile	1.13	(0.62-2.05)	1.14	(0.72-1.81)	0.95	(0.50-1.80)	1.02	(0.62-1.68)	0.87	(0.42-1.80)	0.87	(0.49-1.53)
4th quartile	0.86	(0.48-1.53)	1.59	(0.99-2.57)	0.64	(0.31-1.34)	1.09	(0.59-1.05)	0.63	(0.26-1.54)	0.89	(0.42-1.85)
State Anxiety (mid-pregnancy)	0.99	(0.97-1.01)	1.00	(0.98-1.01)	0.99	(0.96-1.02)	1.00	(0.98-1.03)	0.99	(0.95-1.02)	1.01	(0.98-1.03)
State Anxiety (mid-pregnancy)		p trend = 0.791		p trend = 0.052		p trend = 0.634		p trend = 0.860		p trend = 0.658		p trend = 0.693
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	0.88	(0.42-1.81)	1.41	(0.77-2.58)	0.87	(0.42-1.82)	1.36	(0.73-2.51)	0.90	(0.43-1.93)	1.33	(0.70-2.52)
3rd quartile	1.20	(0.59-2.42)	1.43	(0.82-2.49)	1.26	(0.61-2.60)	1.36	(0.76-2.42)	1.28	(0.56-2.78)	1.30	(0.70-2.43)
4th quartile	1.15	(0.55-2.40)	1.15	(0.65-2.04)	1.14	(0.49-2.66)	0.93	(0.48-1.81)	1.16	0.44-3.03)	0.87	(0.40-1.88)
State Anxiety (late pregnancy)	1.00	(0.98-1.02)	0.99	(0.98-1.01)	1.00	(0.97-1.02)	0.99	(0.97-1.01)	0.99	(0.97-1.02)	0.99	(0.97-1.01)
State Anxiety (late pregnancy)		p trend = 0.858		p trend = 0.653		p trend = 0.907		p trend = 0.709		p trend = 0.794		p trend = 0.944
1st quartile	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent	1.0	Referent
2nd quartile	1.41	(0.74-2.70)	1.14	(0.70-1.86)	1.46	(0.76-2.82)	1.15	(0.70-1.90)	1.53	(0.78-2.99)	1.17	(0.70-1.96)
3rd quartile	1.14	(0.62-2.09)	1.25	(0.77-2.03)	1.16	(0.62-2.15)	1.22	(0.74-2.01)	1.23	(0.63-2.38)	1.20	(0.70-2.05)
4th quartile	1.03	(0.56-1.91)	1.12	(0.69-1.82)	1.13	(0.57-2.28)	1.11	(0.64-1.92)	1.23	(0.56-2.69)	1.04	(0.56-1.94)

CHAPTER 2

GESTATIONAL WEIGHT GAIN AND RISK OF CESAREAN DELIVERY AMONG HISPANIC WOMEN

Abstract

A third of all deliveries in the United States are via cesarean, a rate which has stabilized for most women in the past decade but continues to rise among Hispanic women. Compared to vaginal deliveries, cesareans are associated with significant maternal and fetal morbidity and mortality. At the same time Hispanic women are more likely to exceed Institute of Medicine (IOM) guidelines for gestational weight gain (GWG), compared to non-Hispanic white women. Prior research indicates that excessive GWG may be associated with higher risk for cesarean delivery. Findings are conflicted, however, possibly in part due to variability in measurement of GWG across studies. Therefore, we investigated the association between cesarean delivery and GWG measured in multiple ways: GWG in the 1st trimester, total GWG, rate of GWG in the 2nd and 3rd trimesters, and adherence to IOM guidelines for total GWG and rate of GWG in the 2nd and 3rd trimesters, among 1215 participants in Proyecto Buena Salud, a prospective cohort study of Hispanic pregnant women (16-40 years). Weight and mode of delivery were abstracted from medical records. Women gained an average of 31 pounds during pregnancy (SD=16.2). More than half (52%) of women exceeded and 19% of women gained less than IOM recommendations for total GWG. The majority of women delivered vaginally (77%) and 23% delivered via cesarean. Each additional pound of total GWG was associated with a 2% greater risk of cesarean delivery (RR=1.02, 95% CI 1.01-1.02), after adjusting for age and pre-pregnancy BMI. Each standard deviation

increase in rate of GWG per week in the 2nd and 3rd trimesters was associated with a 34% greater risk of cesarean delivery (RR=1.34 95% CI 1.19-1.52). GWG in the 1st trimester, adherence to IOM guidelines for total GWG and for rate of GWG in the 2nd and 3rd trimesters were not associated with mode of delivery. Findings suggest that rate of GWG in the 2nd and 3rd trimesters, in addition to total GWG, may be helpful in predicting mode of delivery and may provide an early indication of increased risk of cesarean delivery.

Introduction

Cesarean deliveries are associated with increased risk of maternal and fetal morbidity and mortality. Compared to women delivering vaginally, women delivering via cesarean have a higher rate of puerperal febrile morbidity (i.e., "childbed fever"), infection, excessive blood loss, difficulty breastfeeding and a longer stay at the hospital (60–62). In future pregnancies, women who have had a previous cesarean are at higher risk of stillbirth, operative complications, placental abnormalities, risk of uterine rupture and uterine scar dehiscence and hysterectomy (63–65). Infants born via cesarean have higher rates of neonatal respiratory morbidity and hypoglycemia (61,63). Additionally, a delivery via cesarean is strongly associated with the rate of repeat cesareans, currently at approximately 90% (66).

The rate of cesarean delivery has increased dramatically in the United States over the past several decades. The most recently available U.S. data, from 2014, indicates that 32.2% of all births were cesarean deliveries (67). The prevalence of cesarean delivery varies by race and ethnicity. For example, the prevalence among Hispanic women overall was slightly lower than the national average (31.9%). However, when country of origin is considered, the rate of cesarean delivery among Hispanic women of Puerto Rican descent

is higher than the national average (33.9%) (67). Further, secular trends in the prevalence of cesarean deliveries indicated that the rate has stabilized among non-Hispanic black and white women, but continues to increase among Hispanic women (67).

Indications for cesarean delivery include cephalopelvic disproportion, failure to progress, fetal distress, and breech / malposition (68). Maternal pre-pregnancy obesity is an established predictor of cesarean delivery and of excessive GWG (1). Excessive GWG is associated with adverse maternal and infant outcomes and recent evidence suggests that it may be associated with risk of cesarean delivery. The IOM recommends a target range of GWG and rate of GWG for women, depending on their pre-pregnancy BMI (1). Most women do not gain within IOM recommendations. Depending on the population, as many as 70% of women gain more or less than IOM recommendations based on their pre-pregnancy BMI (2,8). Women who are overweight or obese before pregnancy are more likely to gain excessive weight during pregnancy (9). Close to 52% of Hispanic women in the US are overweight or obese at the start of their pregnancy as compared to 44% of non-Hispanic white women (10–13). Therefore Hispanic women are at increased risk of excessive weight, compared to non-Hispanic women.

GWG may contribute to the risk of cesarean delivery via an increase in macrosomia, alterations to estrogen levels, excessive soft tissue formation, and/or provider practices in reaction to excessive GWG during prenatal care and delivery that make cesarean delivery more likely. Twenty-eight prior epidemiological studies examining the association between GWG and the risk of cesarean delivery report conflicting findings, in part due to the differences in the measurement of GWG. For example, few studies used a measure of GWG that accounted for length of gestation and

none of the studies considered weight gain in the first trimester. In addition, prior research has largely failed to include Hispanic women.

Therefore, we investigated the association between GWG measured in several ways (GWG in the 1st trimester, rate of GWG in the 2nd and 3rd trimesters, adherence to IOM guidelines for rate of GWG in the 2nd and 3rd trimesters, total GWG, and adherence to IOM guidelines for total GWG) and the risk of cesarean delivery using data from Proyecto Buena Salud, a prospective cohort study of 1,610 Hispanic pregnant women.

Physiology

Research on the physiological mechanism for the increased risk of cesarean delivery associated with inadequate or excessive GWG is sparse but includes: 1) an increase in macrosomia, 2) low or high estrogen levels, 3) excess soft tissue, and 4) provider practices in response to excessive GWG during prenatal care and delivery that make a cesarean delivery more likely (69,70).

Regarding the first potential mechanism, excessive GWG, particularly during the second and third trimesters, is an established risk factor for macrosomia, which in turn has been associated with increased risk of cesarean delivery due primarily to cephalopelvic disproportion (3,68,69). Excessive weight gain, therefore, may increase the risk of cesarean delivery through an increase in macrosomic infants.

For the second potential mechanism, women with inadequate or excessive GWG have more or less adipose tissue than women gaining within IOM guidelines. During the first trimester, excess maternal weight contributes relatively more to maternal adipose tissue, while in the second and third trimesters it contributes relatively more to fetal size (1). Adipose tissue is a source of estrogen, and therefore women with excessive or

inadequate adipose tissue may have estrogen levels that are higher or lower than typical pregnancy levels. Estrogen is involved in prostaglandin production and increases responsiveness of oxytocin receptors, both of which are hormones that are essential to a successful vaginal delivery (including cervical dilation) (71). Estrogen is additionally involved in myometrium growth and stimulates the growth of gap junctions between myometrial cells, which together are required for effective and coordinated contractions during labor and delivery (71). Therefore, the hormonal imbalance resulting from inadequate or excessive adipose tissue, particularly related to weight gain in the first trimester, may make vaginal delivery difficult and require the use of cesarean delivery.

Regarding the third potential mechanism, excessive GWG may lead to the development of excess and/or thick soft maternal tissue, particularly in the pelvis, that physically interferes with a woman's ability to have a successful vaginal birth (71,72). Again, excessive weight gain during the first trimester may particularly contribute to soft tissue because weight gain during the first trimester contributes relatively more to adipose and soft maternal tissue, compared to weight gain after the first trimester (1). Cephalopelvic disproportion, or the inability of the fetus to fit through the mother's pelvic opening, is a primary indication for cesarean deliveries among women with excessive GWG and excess soft tissue formation in the pelvis may contribute to a mismatch in infant size and pelvic opening (73).

Finally, regarding the fourth potential mechanism, providers may be more likely to recommend a cesarean delivery to a woman with inadequate or excessive weight gain, as compared to a woman who gains within IOM guidelines. Prior studies suggest that providers may assume that a woman with excessive GWG will have a more difficult

labor and may encourage a planned cesarean before labor begins, or may more quickly recommend a cesarean during labor (citing failure to progress or cephalopelvic disproportion), compared to women who gain within IOM guidelines (74).

Epidemiology

In the last decade, 28 epidemiological studies have examined the association between GWG and cesarean delivery. The studies were fairly evenly split between retrospective cohort studies (68,69,75–87) and prospective cohort studies (8,70,88–96). The majority of studies found that compared to GWG within IOM guidelines, excessive GWG was associated with an increased risk of cesarean delivery (2,8,68–70,75,81–88,91–96). Six studies found that inadequate GWG was associated with decreased risk of cesarean delivery, compared to within IOM guidelines (75,88,92,93,95,96). About a third of studies found no association (76–80,89,90,97).

Variability in measurement and categorization of GWG may contribute, in part, to conflicting findings. Only 7 of the 28 studies in the last 10 years have categorized GWG according to the most recent IOM guidelines (2,8,79,87,94–96). Other common categorizations included the 1990 IOM guidelines (69,90,97), quartiles of GWG (91), subjective categorization of low, medium and high GWG (and occasionally also "very high") (68,70,75,77,78,80–82,84,86,88,92,93), or Canadian GWG guidelines (76,89), all of which are based on total GWG. Total GWG may be a biased measure due to its inherent correlation with length of gestation, which is an established risk factor for various adverse birth outcomes including low birth weight or macrosomia, neonatal respiratory distress and stillbirth (98).

Because GWG is typically minimal during the first trimester and approximately linear during the second and third trimesters, weight gained in the first trimester and rate of weight gained (e.g., lbs/week) in the 2nd and 3rd trimesters may be important risk factors for cesarean delivery. In addition rate of GWG in the 2nd and 3rd trimesters removes the inherent correlation with length of gestation, as described above. Two studies considered rate of GWG, one of which examined rate of GWG over entire pregnancy (83) and one of which examined rate of GWG in the 2nd and 3rd trimesters (85), as suggested by the 2009 IOM guidelines for biological relevance (1). None of the prior studies examined weight gained in the first trimester only.

Of the 28 studies, 6 of the studies did not state the racial and ethnic make-up of their study population (2,75,79,87,89,93) and only 12 included any Hispanic participants (69,70,78,82,84–87,90,91,94,97). Of those 12 studies, only 2 included a substantial proportion of Hispanic women in the study sample (52% and 71%), although the specific Hispanic heritage was not stated (78,87).

In the study with the largest proportion of Hispanic women in the sample, Yee et al. conducted a retrospective cohort study among 2,310 overweight and obese women living in California (71% Hispanic) with pre-existing type 2 diabetes and singleton pregnancies between 2001 and 2004. Total GWG was assessed as weight measured at the last clinic visit prior to delivery minus self-reported pre-pregnancy weight and categorized according to compliance with IOM guidelines. Mode of delivery was abstracted from participant's medical records and was considered in two ways: 1) total number of cesareans among the women, regardless of prior history, and 2) number of primary (a woman's first) cesareans (87).

The authors found that excessive GWG was associated with a 47% greater risk of all cesarean deliveries (RR=1.47; 95% CI 1.03-2.10) and a 62% greater risk of primary cesarean delivery (RR=1.62; 95% CI 1.03-2.57)(87), as compared to weight gain within IOM guidelines after adjusting for maternal age, race, parity and level of education.

This study, while it included a large proportion of Hispanic women, was limited by the specific population under study. All women were diagnosed with diabetes and were overweight before pregnancy, a population that may be unique in terms of the biological determinants and consequences of GWG. This study was also limited by the single measure of GWG used: while compliance with IOM guidelines does account for pre-pregnancy BMI, it does not account for length of gestation.

Hypotheses

Specific Aim 1: To evaluate the association between GWG and cesarean delivery in a population of Hispanic women.

Hypothesis 1a: GWG in the first trimester and total GWG is positively associated with cesarean delivery.

Hypothesis 1b: Excessive total GWG according to IOM guidelines is associated with an increased risk of cesarean delivery, compared to total GWG within guidelines.

Hypothesis 1c: Inadequate total GWG according to IOM guidelines is associated with a decreased risk of cesarean delivery, compared to total GWG within guidelines.

Specific Aim 2: To evaluate the association between rate of GWG in the 2nd and 3rd trimesters and cesarean delivery in a population of Hispanic women.

Hypothesis 2a: Rate of GWG in the 2nd and 3rd trimesters is positively associated with cesarean delivery.

Hypothesis 2b: Excessive rate of GWG in the 2nd and 3rd trimesters according to IOM guidelines is associated with an increased risk of cesarean delivery, compared to rate of GWG in the 2nd and 3rd trimesters within IOM guidelines.

Hypothesis 2c: Inadequate rate of GWG in the 2nd and 3rd trimesters according to IOM guidelines is associated with a decreased risk of cesarean delivery, compared to rate of GWG in the 2nd and 3rd trimesters within guidelines.

Methods

Study Design

We examined the association between GWG and cesarean delivery using data from Proyecto Buena Salud (PBS), a prospective cohort study of Hispanic prenatal care patients at Baystate Medical Center in Springfield, Massachusetts from January 2006 through October 2010. Bilingual interviewers (Spanish and English) recruited patients at a prenatal care visit early in pregnancy (before 20 weeks gestation). Pregnant women were informed regarding the aims and procedures of the study and provided written informed consent approved by the Institutional Review Boards of the University of Massachusetts Amherst and Baystate Medical Center. The study consisted of three structured interviews, conducted in Spanish or English (based on the participant's preference) as well as medical record review. The first interview (early pregnancy) occurred at the time of enrollment (between 6 and 18 weeks gestation). The second (mid-

pregnancy) interview occurred between 18.1 and 26 weeks gestation. The final (late pregnancy) interview occurred between 26.1 and 43 weeks gestation (Figure 1). Medical records were abstracted after delivery for clinical characteristics of the current pregnancy and medical and obstetrical history.

Study Population

Women were eligible to participate in PBS if they were of Puerto Rican or Dominican Republic heritage, defined as having been born in the Caribbean Islands, having a parent who was born in the Caribbean Islands or having two grandparents who were born in the Caribbean Islands. Exclusion criteria included 1) taking medications thought to adversely influence glucose tolerance, 2) multiple gestation, 3) history of diabetes, hypertension, heart disease or chronic renal disease and 4) <16 or >40 years of age at enrollment. For the purpose of this analysis, women were excluded if information on GWG is missing, or if they have had a spontaneous or therapeutic abortion, a stillbirth, a preterm birth (<37 weeks gestation) or a late term birth (>42 wks gestation), as their GWG and mode of delivery would likely not be comparable to women who delivered a live fetus at term (37-42 weeks gestation).

Exposure Assessment

A clinical weight was recorded for participants at each prenatal care visit during their pregnancy and at the time of delivery. The measured weights and the corresponding gestational age at which the weights were measured were abstracted from medical records.

GWG is assumed to minimal in the 1st trimester (2.2 – 4.4 lbs) and approximately linear in the 2nd and 3rd trimesters, and was therefore considered independently (1). GWG

in the 1st trimester was calculated as the difference between weight measured at the prenatal visit closest to 13 weeks gestation and pre-pregnancy weight (as self-reported in medical records). When pre-pregnancy weight was not available from medical records, self-reported pre-pregnancy weight was used from the interview in early pregnancy. GWG in the 1st trimester was analyzed as a continuous variable (Table 2.1).

Total GWG was abstracted from medical records after delivery, and was calculated as the difference between measured maternal weight at delivery and pre-pregnancy weight (as described above). Total GWG was analyzed as a continuous variable. Total GWG was additionally categorized according to IOM guidelines: inadequate (gaining less than the recommended minimum), within guidelines (gaining within the recommendation), and excessive (gaining more than the recommended maximum). IOM guidelines vary according to pre-pregnancy BMI and are as follows: women with a BMI <18.5 kg/m^2 are advised to gain 28-40 lbs, women with a BMI of 18.5-24.9 kg/m^2 are advised to gain 25-35 lbs, women with a BMI of 25.0-29.9 kg/m^2 are advised to gain 15-25 lbs, and women with a BMI ≥30.0 kg/m^2 are advised to gain 11-20 lbs (Table 1.2) (1).

Rate of GWG in the 2nd and 3rd trimesters was calculated as the difference between weight at delivery and weight at the prenatal visit closest to 13 weeks gestation, divided by weeks of gestation within that time period (Table 2.1). Weight in the 2nd and 3rd trimesters was evaluated because GWG is assumed to be minimal in the first trimester (2.2 – 4.4 lbs) and then linear in the second and third trimesters, as stated previously (1). Rate of GWG in the 2nd and 3rd trimesters was analyzed as a continuous variable, both in terms of each additional pound per week and in terms of a standard deviation increase in

rate of GWG each week, and was additionally categorized according to IOM guidelines: inadequate, within guidelines and excessive. IOM guidelines indicate that after the first trimester, women with a BMI <18.5 kg/m^2 are advised to gain 1.0-1.3 lbs per week, women with a BMI of 18.5-24.9 kg/m^2 are advised to gain 0.8-1.0 lbs per week, women with a BMI of 25.0-29.9 kg/m^2 are advised to gain 0.5-0.7 lbs per week, and women with a BMI ≥30.0 kg/m^2 are advised to gain 0.4-0.6 lbs per week (Table 1.2) (1).

Data on delivery weight was collected from medical records from a trained abstractor, and is considered the "gold standard" (1). Pre-pregnancy weight (self-reported at the first prenatal care visit) was also abstracted from medical records after delivery. Self-reported pre-pregnancy weight is commonly used in epidemiologic studies of GWG because preconception weight measures typically do not exist in medical record data and the IOM presents it as a practical method of measuring pre-pregnancy weight (1). Prior studies have found that self-reported pre-pregnancy weight is highly correlated with measured pre-pregnancy weight (r=0.95, r=0.98) and that self-reported pre-pregnancy weight is underreported by about 1kg on average (50–52). Further, BMI calculated from self-reported weight and measured weight had good agreement (76.4% for underweight, 85.3% for normal weight, 75.7% for overweight, 71.9% for obese and 93.1% for severely obese) (53).

Outcome Assessment

Mode of delivery was abstracted from medical records after delivery, and was analyzed as a dichotomous variable (cesarean delivery – yes or no) (Table 2.1). Prior studies have stratified by unplanned and planned cesarean deliveries. An unplanned cesarean is likely to be decided upon by the provider after the start of labor. A planned

cesarean, by contrast, does not involve labor and is scheduled to occur before spontaneous labor. Therefore, presence of labor was abstracted from medical records and was used as a proxy for planned vs. unplanned cesareans.

Data on mode of delivery was abstracted from medical records by a trained abstractor, and is considered the "gold standard." Nearly all previous epidemiological studies examining the association between GWG and cesarean delivery use medical record abstraction to collect information on mode of delivery (2,8,68,75–81,83–89,91,92,95–97).

Covariate Assessment

Potential covariates were selected based on inclusion in prior literature (31), and potential for effect modification and/or confounding. Marital status, number of adults and children in the household, smoking during early pregnancy, alcohol consumption during early pregnancy, morning sickness during early pregnancy, education, income, generation in the United States, and acculturation (measured via the Psychological Acculturation Scale)(57) were obtained through interviews conducted at baseline (Table 2.1). Depression, stress, and anxiety in early, mid- and late pregnancy were assessed via the Edinburgh Depression Scale, the Perceived Stress Scale and the State-Trait Anxiety Inventory, respectively. Physical activity (MET hrs/week) was measured via the Pregnancy Physical Activity Questionnaire)(54) at early, mid- and late pregnancy. Total energy intake was measured once during mid-pregnancy via 24-hour diet recalls. Gravidity, parity, age, pre-pregnancy BMI, fetal birth weight, gestational age at delivery, presence of labor, and history of macrosomic infants were abstracted from medical records (Table 2.1). Final multivariable models will include important confounders

included in prior literature (i.e., age and pre-pregnancy BMI) (2,8,68,75–81,83–89,91,92,95–97) and potential confounders that change the estimate by more than 10%.

Data Analysis

To address both specific aims 1 and 2, we calculated the number and percent of participants included in the study sample, the distribution of GWG variables (GWG in the 1st trimester, rate of GWG in 2nd and 3rd trimesters, adherence to IOM guidelines for GWG in the 2nd and 3rd trimesters, total GWG and adherence to IOM guidelines for total GWG), and the distribution mode of delivery.

Potential confounders were assessed by cross-tabulating covariates by all GWG variables and by mode of delivery. Chi-square tests for categorical variables and t-tests for continuous variables were used, and associated p-values are reported. Fisher's Exact Test was used in the case of small cell sizes.

Unadjusted logistic regression models were used to model associations between GWG variables and mode of delivery. Relative risks and 95% confidence interval are reported.

The final models were developed using multivariable logistic regression models, adjusting for important covariates and confounders (as outlined previously) and covariates causing a 10% or greater change in estimate. Relative risks and 95% confidence intervals are reported. Relative risks were estimated from model estimated odds ratios using the methods described by Zhang and Yu because the outcome is not rare (99). All analyses were complete case analyses.

As previous studies have done, we compared vaginal deliveries to unplanned cesarean deliveries by excluding all planned cesareans (60,86). To this end, we repeated

the final models excluding cesareans that occurred without the presence of labor (a proxy for planned cesareans).

We also stratified the final models by parity (i.e. parous vs. nulliparous) to test for effect modification and to address possible confounding by previous cesarean as previous studies have done (80,83).

Results

A total of 1,583 participants were recruited into PBS. The final sample for analysis included 1,215 Hispanic women, after removing 37 women who were missing information on GWG, 65 women who had a spontaneous or therapeutic abortion, 17 women who had a stillbirth, 124 women who had a preterm birth, 1 woman who had a late term birth, and 124 women missing information on mode of delivery (Table 2.2).

The average weight gain among participants during the first trimester was 3.8 lbs (SD=7.9 lbs). Average total weight gain was 31.0 pounds (SD=16.2 lbs). Only about 29% of women gained within the IOM recommended range based on their pre-pregnancy BMI. More than half of the women (nearly 52%) gained excessive weight and just under 20% of women failed to gain enough weight (Table 2.3). Women gained 1.03 pounds per week, on average (SD=0.50). Only about 17% of women gained within IOM guidelines for rate of GWG in the 2nd and 3rd trimesters based on their pre-pregnancy BMI. About two-thirds of women (63%) exceeded the IOM guideline for rate of GWG in the 2nd and 3rd trimesters and about 20% of women fell below the IOM guideline for rate of GWG in the 2nd and 3rd trimesters (Table 2.3).

Nearly three-quarters of the women had a vaginal delivery (n=937, 77%) (Table 2.4) (67). Of the 23% of women who delivered via cesarean (n=278), about 61% of those women (n=169) labored before the cesarean delivery.

We evaluated participant characteristics according to each GWG variable: GWG in the 1st trimester (Table 2.5a), rate of GWG in the 2nd and 3rd trimesters (Table 2.5c) and total GWG (Table 2.5b). Age, infant birth weight, parity and gravidity were associated with all GWG variables. Stress was associated with GWG in the 1st trimester, and length of residency in the US, number of children in the household, morning sickness in early pregnancy and alcohol consumption in early pregnancy were associated with rate of GWG in the 2nd and 3rd trimesters and with total GWG. Income was associated with only total GWG. Women with a normal pre-pregnancy BMI had a greater rate of GWG in the 2nd and 3rd trimesters and had the greatest total GWG, compared to women in other pre-pregnancy BMI categories. Women who did not smoke during early pregnancy had a greater rate of GWG in the 2nd and 3rd trimesters, compared to women who did smoke (Table 2.5a, Table 2.5b and Table 2.5c).

We also evaluated participant characteristics according to mode of delivery (Table 2.6). Cesarean delivery was more common among older women, compared to younger women. Infants delivered via cesarean weighed more on average and were born at slightly earlier gestational age than infants delivered vaginally. Increasing pre-pregnancy BMI was positively associated with cesarean deliveries and vaginal deliveries were more common among women with pre-pregnancy BMI in the normal range. Increasing gravidity was also associated with delivering via cesarean.

Final multivariable models included age and pre-pregnancy BMI as confounders, both of which were selected because of their established role as confounders in prior literature. No other potential confounders changed the estimate by more than 10%. Increasing GWG in the first trimester was not significantly associated with the risk of cesarean delivery, before (RR=1.01, 95% CI 1.00-1.01) or after (RR=1.01, 95% CI 1.00-1-.01) adjusting for age and pre-pregnancy BMI (Table 2.7).

In regards to rate of GWG in the 2nd and 3rd trimesters (Table 2.7), each additional pound per week of weight during the 2nd and 3rd trimesters was associated with an 82% higher risk of cesarean delivery (RR=1.82, 95% CI 1.42-2.27). Each additional standard deviation increase in rate of GWG was associated with a 34% higher risk of cesarean delivery (RR=1.34, 95% CI 1.19-1.52). There were no significant associations between adherence to IOM guidelines for rate of GWG 2nd and 3rd trimesters and risk of cesarean delivery.

Similarly, each additional pound of total GWG was associated with a 2% higher risk of cesarean delivery (RR=1.02, 95% CI 1.01-1.02) after adjusting for age and pre-pregnancy BMI (Table 2.7). We also examined the association between adherence to IOM guidelines for total GWG. Inadequate GWG was not associated with risk of cesarean delivery, but excessive weight gain was significantly associated. Women with excessive total weight gain had a 41% higher risk of cesarean delivery, compared to women gaining within IOM guidelines (RR=1.41, 95% CI 1.10-1.78), which dropped to a 15% higher risk after adjusting for age and pre-pregnancy BMI (RR=1.15, 95% CI 1.05-1.73).

We conducted a sensitivity analysis restricting the sample to only women who had the presence of labor before the cesarean delivery, as a proxy for unplanned cesareans (Table 2.8). We found the same associations in this sub-sample as we found in the full sample. There was no association between GWG in the 1st trimester and risk of cesarean delivery. Every one pound increase in the rate of GWG in the 2nd and 3rd trimesters was associated with an 89% higher risk of cesarean delivery (RR=1.89 95% CI 1.42-2.43), and every one standard deviation increase is rate of GWG in the 2nd and 3rd trimesters was associated with a 37% higher risk of cesarean delivery (RR=1.37, 95% CI 1.19-1.58). Adherence to IOM guidelines for rate of GWG in the 2nd and 3rd trimesters was not associated with risk of cesarean delivery. In regards to total GWG, every additional pound gained was associated with a 2% higher risk of cesarean delivery (RR=1.02, 95% 1.01-1.02). Adherence to IOM guidelines for total GWG was not associated with risk of cesarean delivery.

Lastly, we stratified our final model by parity (Table 2.9). We found the same pattern of results among nulliparous and parous women. In regards to rate of GWG in the 2nd and 3rd trimesters, among nulliparous women each additional pound of weight gained per week in the 2nd and 3rd trimesters was associated with an 80% higher risk of cesarean delivery (RR=1.80, 95% CI 1.22-2.50) and each additional standard deviation increase in rate of GWG in the 2nd and 3rd trimesters per week was associated with a 34% higher risk of cesarean delivery (RR=1.34, 95% CI 1.10-1.61). GWG in the 1st trimester, total GWG, adherence to IOM guidelines for total GWG and adherence to IOM guidelines for rate of GWG in the 2nd and 3rd trimesters were not significantly associated with risk of cesarean delivery. Similarly, among parous women, each additional pound of total weight

gained was associated with a 2% higher risk of cesarean delivery (RR=1.02, 95% CI 1.01-1.02), each additional pound of weight gained per week in the 2nd and 3rd trimesters was associated with a 75% higher risk of cesarean delivery (RR=1.75, 95% CI 1.23-2.36) and each additional standard deviation increase in rate of GWG in the 2nd and 3rd trimesters was associated with a 32% higher risk of cesarean delivery (RR=1.32, 95% CI 1.10-1.55). GWG in the 1st trimester, adherence to IOM guidelines for total GWG and adherence to IOM guidelines for rate of GWG in the 2nd and 3rd trimesters were not significantly associated with risk of cesarean delivery.

Discussion

In summary, in this prospective cohort study among Hispanic prenatal care patients, we found, after adjusting for important covariates including age and pre-pregnancy BMI, that increased total GWG and increased rate of GWG in the 2nd and 3rd trimesters were associated with an higher risk of cesarean delivery. We did not find evidence for an association between weight gained in the 1st trimester, adherence to IOM guidelines for total GWG and adherence to IOM guidelines for rate of GWG in the 2nd and 3rd trimesters and risk of cesarean delivery.

Our finding that higher GWG was associated with greater risk of cesarean delivery is consistent with and expands upon the results of prior research, including the retrospective cohort study by Yee and colleagues (87). The study included 2, 310 pregnant women who were overweight or obese and diabetic before pregnancy, 70% of whom were Hispanic. The authors found that excessive total GWG according to the 2009 IOM guidelines was associated with a 47% higher risk of all cesarean deliveries (RR=1.47; 95% CI 1.03-2.10) and a 62% higher risk of primary cesarean delivery

(RR=1.62; 95% CI 1.03-2.57), as compared to weight gain within IOM guidelines after adjusting for maternal age, race, parity and level of education (87). Similarly, we found that excessive total GWG was associated with a 15% higher risk of cesarean delivery.

In the only prior study to examine rate of GWG in the 2nd and 3rd trimesters specifically, Durie and colleagues found that women with excessive rate of GWG in the 2nd and 3rd trimesters had an greater risk of cesarean delivery, except among women (less than 7% Hispanic) who were underweight or obese class III before pregnancy (85). Women with an excessive rate of GWG in the 2nd and 3rd trimesters had a 38% (for women with normal pre-pregnancy BMI, OR=1.38, 95% confidence interval 1.26–1.51), 45% (for women who were overweight pre-pregnancy, OR=1.45, 95% confidence interval 1.23–1.71), 36% (for women who were obese class I pre-pregnancy, OR=1.36, 95% confidence interval 1.11–1.67), and 39% (for women who were obese class II pre-pregnancy, OR=1.39, 95% confidence interval 1.08–1.79) higher risk of cesarean delivery, compared to women who gained within IOM guidelines for rate of GWG in the 2nd and 3rd trimesters. We similarly found that increased rate of GWG in the 2nd and 3rd trimesters was associated with an greater risk of cesarean delivery, adjusted for age and pre-pregnancy BMI (RR=1.82, 95% CI 1.42-2.27 for each additional pound per week gained).

Our study had several strengths. We examined the association between GWG and risk of cesarean delivery among pregnant Hispanic women from the Caribbean Islands, a population underrepresented in prior literature examining this association, but who are at particularly high risk of both extreme weight gain and cesarean delivery. Our study was prospective in nature, allowing us to assess temporality in the association between GWG

and mode of delivery. We were able to define GWG in several ways, expanding upon the definition of GWG, including biologically relevant weight gain time period (i.e., weight gain in the 1st trimester) and allowing for measures of weight gain that are not correlated with length of gestation (i.e. rate of GWG in the 2nd and 3rd trimesters). We were able to examine GWG both continuously and in categories according to adherence to IOM guidelines. Therefore, we were able to gain a unique understanding of when during pregnancy women gain was most influential in regards to mode of delivery.

However, our study also had several limitations. Firstly, a nondifferential misclassification of the exposure is possible. GWG is ascertained through abstraction of medical records. Self-reported pre-pregnancy weight is recorded by health professionals at the first prenatal visit. As previously discussed, self-reported pre-pregnancy weight has been found to differ from measured pre-pregnancy weight, and this may result in some nondifferential misclassification of both total GWG and adherence to IOM guidelines if pre-pregnancy BMI is misclassified. Women both under- and over-report pre-pregnancy weight. In addition, weight is measured at every prenatal visit and upon admission to the hospital during labor, although for clinical and not research purposes. Misclassification could occur due to scale calibration issues, women wearing clothing and shoes of various weights. The misclassification in pre-pregnancy weight may lead to misclassification in pre-pregnancy BMI and GWG calculations. It is likely, therefore, that the exposure was misclassified and the results of the study were biased toward the null. We expect the impact of this was modest, however, because prior studies have found that self-reported pre-pregnancy weight is highly correlated with measured pre-pregnancy weight. It is

unlikely that the outcome, mode of delivery, was misclassified, as it was abstracted from medical records.

Secondly, a selection bias could have occurred if there was differential loss to follow-up. However, differential loss to follow-up is unlikely due to the ascertainment of outcome through abstraction of medical records, and would have been minimal, as eligibility criteria were limited to those planning to deliver at the study hospital. Further, in many cases, the medical records of participants delivering at another hospital were requested and obtained.

Finally, given the number of GWG variables examined, we cannot rule out chance as explanation for the observed significant findings. In this case, it is critical that the interpretation of the findings from each individual model be interpreted conservatively and in light of a feasible biologic rationale. However, only a minority of p values were statistically significant. In addition, the GWG variables used have a likely potential physiological connection with the outcome.

We tested a number of variables as confounders that have been identified in previous studies and important confounders were included in final multivariable models. Age and pre-pregnancy BMI were always included in final models. Residual confounding was possible if the confounders were inaccurately measured. There was also the possibility for residual confounding by unmeasured confounders. For example, data was not collected on history of cesarean delivery. Previous cesarean delivery is strongly positively associated with cesarean delivery in the current pregnancy and may be positively associated with GWG (1). Therefore, our inability to control for history of cesarean delivery could have led to an overestimate of the relative risk. However, to

address this concern, we repeated our analysis among nulliparous women only and found the same pattern of results.

The results of this study may be generalized to pregnant women from the Caribbean Islands. Our results may not be generalized to pregnant women who have multiple births, as our study was restricted to mothers with singleton births. Multiple births increase GWG and the likelihood of a cesarean delivery. The biological mechanism linking GWG to mode of delivery may not vary by racial/ethnic group, but socioeconomic, sociocultural factors and healthcare utilization and access, and provider practices may vary by racial/ethnic group, and therefore our findings may not be generalized to non-Hispanic populations or other Hispanic subgroups.

In summary, we found that increased rate of GWG in the 2nd and 3rd trimesters and high total GWG was associated with an higher risk of cesarean delivery. These findings suggest that decreasing total weight gain and in particular, rate of GWG in the 2nd and 3rd trimesters of pregnancy, may lower the risk of cesarean delivery. A healthy rate of weight gain during the 2nd and 3rd trimesters may be a critical period in terms of impacting mode of delivery and suggest a target for an intervention designed to reduce the use of cesarean deliveries.

Table 2.1. Classification of Study Variables: Proyecto Buena Salud, 2006-2010.

Name	Description	Type
Outcome Variables		
del_type	Mode of Delivery 1=vaginal 2=cesarean	Dichotomous
Exposure Variables		
GWG_1ST	Gestational Weight Gain During 1st Trimester	Continuous
TOT_GWG	Total Gestational Weight Gain	Continuous
IOM_TOT	Met IOM, Total Gestational Weight Gain 0=within recommendations 1=inadequate 2=excessive	Categorical
RATE_GWG	Rate of Gestational Weight Gain, 2nd and 3rd Trimesters	Continuous
IOM_RATE	Met IOM, Rate Gestational Weight Gain, 2nd and 3rd Trimesters 0=within recommendations 1=inadequate 2=excessive	Categorical
Covariates		
age_gp	Age 1=16-19 2=20-24 3=25-29 4=≥30	Categorical
married	Marital Status 1=Single/Separated/Divorced/Widowed 2=Married 3=Refused	Categorical
ed	Education 1=Less than high school 2=High school graduate or GED 3=Post high school	Categorical
income	Income 1=≤$15,000 2=>$15,000-$30,000 3=>$30,000 4=don't know/refuse	Categorical
adults	Number of Adults in Household 0=1 1=1 2=2 3=≥3	Categorical

Table 2.1., continued.

Name	Description	Type
kids	Number of Children in Household 0=1 1=1 2=2 3=≥3	Categorical
acc_status	Acculturation 1=low (1-<3) 2=high (≥3)	Dichotomous
generation	Generation in US 1=Born in PR/DR 2=Parent born in PR/DR 3=Grandparent born in PR/DR	Categorical
pregsmoke_early	Smoking During Early Pregnancy 0=None 1=<=10 cigs/day 2=Over 10 cigs/day	Categorical
pregalc_early	Alcohol Consumption During Early Pregnancy 0=no 1=yes	Dichotomous
eds_2_1	Probable Major Depression, Early Pregnancy 0=no 1=yes	Dichotomous
eds_2_2	Probable Major Depression, Mid Pregnancy 0=no 1=yes	Dichotomous
eds_2_3	Probable Major Depression, Late Pregnancy 0=no 1=yes	Dichotomous
ta	Trait Anxiety, Early Pregnancy	Continuous
sa2	State Anxiety, Mid Pregnancy	Continuous
sa3	State Anxiety, Late Pregnancy	Continuous
pss1	Stress, Early Pregnancy	Continuous
pss2	Stress, Mid Pregnancy	Continuous
pss3	Stress, Late Pregnancy	Continuous
PA_early	Total Physical Activity, Early Pregnancy (MET hrs/week)	Continuous
PA_mid	Total Physical Activity, Mid Pregnancy (MET hrs/week)	Continuous

Table 2.1., continued.

Name	Description	Type
PA_late	Total Physical Activity, Late Pregnancy (MET hrs/week)	Continuous
c_msick	Morning Sickness in Early Pregnancy 0=no 1=yes	Dichotomous
birth_wt	Infant Birth Weight (grams)	Continuous
GA_delivery	Gesational Age of Infant at Delivery	Continuous
c_labor	Presence of Labor (Among Cesareans) 1=labor 2=no labor	Dichotomous
bmi_gp	Pre-Pregnancy BMI 1= <18.5 2= 18.5-<25 3= 25-<30 4= ≥30	Categorical
gravidity	Gravidity 0=0 previous pregnancies 1=1 previous pregnancy 2=2 or more previous pregnancies	Categorical
parity	Parity 0=0 live births 1=1 live birth 2=2+ live births	Categorical

Table 2.2. Number and Percent in Final Sample: Proyecto Buena Salud, 2006-2010.

Original Study Sample	1583	
Excluded		
Missing information on gestational weight gain	37	2.34%
Spontaneous or therapeutic abortion	65	4.11%
Stillbirth	17	1.07%
Preterm birth (<37 weeks GA)	124	7.83%
Missing information on mode of delivery	124	7.83%
Late term birth (>42 weeks GA)	1	0.1%
Final Sample Size	1215	76.75%

Table 2.3. Distribution of Gestational Weight Gain Variables: Proyecto Buena Salud, 2006-2010.

Gestational Weight Gain During 1st Trimester (lbs)	944	
Mean (SD)		3.8 (7.9)
Total Gestational Weight Gain (lbs)	1188	
Mean (SD)		31.0 (16.2)
Adherence to IOM Guidelines for Total Weight Gain	1168	
Inadequate Gestational Weight Gain	227	19.43%
Within Guidelines	335	28.68%
Excessive Gestational Weight Gain	606	51.88%
Rate of Gestational Weight Gain (lbs/week)	936	
Mean (SD)		1.03 (0.47)
Adherence to IOM Guidelines for Rate of Weight Gain	934	
Inadequate Gestational Weight Gain	186	19.91%
Within Guidelines	156	16.70%
Excessive Gestational Weight Gain	592	63.38%

Table 2.4. Distribution of Mode of Delivery: Proyecto Buena Salud, 2006-2010.

Mode of Delivery				
Vaginal	937	77.12%		
Cesarean	278	22.88%		
No labor before cesarean			107	38.49%
Labor before cesarean			169	60.79%
Unknown			2	0.72%

Table 2.5a. Distribution of Covariates According to GWG in 1st trimester: Proyecto Buena Salud, 2006-2010.

	GWG, 1st Tri (continuous)		
	M	SD	p-value
Demographics			
Age			**p<0.001**
16-19	2.6	(7.6)	
20-24	3.5	(8.3)	
25-29	5.5	(7.8)	
≥30	5.7	(7.4)	
Marital Status			p=0.089
Single/Separated/Divorced/Widowed	3.5	(8.0)	
Married	4.7	(7.8)	
Refused	7.1	(6.6)	
Education			p=0.138
less than high school	3.5	(7.9)	
high school graduate or GED	3.4	(8.2)	
post high school	4.8	(7.9)	
Income			p=0.087
≤$15,000	3.5	(7.9)	
>$15,000-$30,000	4.4	(7.2)	
≥$30,000	6.1	(8.5)	
don't know/refuse	3.4	(8.2)	
Number of Adults in Household			p=0.186
1	4.2	(8.1)	
2	4.0	(7.7)	
≥3	2.9	(8.6)	
Number of Children in Household			p=0.962
0	4.0	(7.4)	
1	3.7	(7.8)	
2	3.7	(8.4)	
≥3	3.9	(8.6)	
Acculturation			p=0.512
low (1-<3)	-3.8	(8.0)	
high (≥3)	3.4	(7.9)	
Generation in US			p=0.138
born in PR/DR	3.5	(7.9)	
parent born in PR/DR	5.7	(8.9)	
grandparent born in PR/DR	4.0	(7.9)	
Behavioral Characteristics			
Smoking During Early Pregnancy			p=0.543
None	3.8	(8.0)	
≤10 cigs/day	4.8	(8.7)	
>10 cigs/day	5.8	(9.7)	
Alcohol Consumption During Early Pregnancy			p=0.630
no	3.9	(8.0)	
yes	5.1	(9.2)	
Probable Major Depression, Early Pregnancy			p=0.424
no	4.1	(7.9)	
yes	3.4	(8.6)	

Table 2.5a., continued.

	GWG, 1st Tri (continuous)		
	M	SD	p-value
Probable Major Depression, Mid Pregnancy			p=0.620
no	3.4	(7.6)	
yes	3.8	(7.2)	
Probable Major Depression, Late Pregnancy			p=0.141
no	3.5	(7.8)	
yes	5.0	(7.2)	
Anxiety, Early Pregnancy			p=0.227
Mean (SD)	40.2	(10.5)	
Anxiety, Mid Pregnancy			p=0.185
Mean (SD)	34.1	(11.7)	
Anxiety, Late Pregnancy			p=0.266
Mean (SD)	33.1	(11.6)	
Stress, Early Pregnancy			**p=0.044**
Mean (SD)	26.1	(7.2)	
Stress, Mid Pregnancy			p=0.689
Mean (SD)	25.2	(7.5)	
Stress, Late Pregnancy			p=0.706
Mean (SD)	23.8	(7.8)	
Physical Activity, early pregnancy (METS/wk)			p=0.493
Mean (SD)	184.9	(137.2)	
Physical Activity, mid pregnancy (METS/wk)			p=0.995
Mean (SD)	184.1	(126.9)	
Physical Activity, late pregnancy (METS/wk)			p=0.335
Mean (SD)	168.7	(102.2)	
Characteristics of Pregnancy			
Morning Sickness in Early Pregnancy			p=0.024
no	4.7	(7.9)	
yes	3.3	(8.0)	
Infant Birth Weight (grams)			**p=0.004**
Mean (SD)	3317.0	(446.1)	
Gesational Age of Infant at Delivery (weeks)			p=0.881
Mean (SD)	39.7	(1.1)	
Presence of Labor before Cesarean			p=0.319
No Labor	5.1	(8.6)	
Labor	4.0	(7.4)	
Medical History			
Pre-Pregnancy BMI			**p<0.001**
<18.5	5.8	(5.1)	
18.5-<25	4.5	(7.6)	
25-<30	4.2	(8.6)	
≥30	1.8	(8.1)	
Gravidity			**p=0.009**
1 total pregnancy	2.9	(7.6)	
2 total pregnancies	3.4	(8.2)	
3+ total pregnancies	4.7	(8.0)	
Parity			**p=0.004**
0 live births	3.1	(7.6)	
1 live birth	3.5	(8.1)	
≥2 live births	5.2	(8.2)	

Table 2.5b. Distribution of Covariates According to Total GWG: Proyecto Buena Salud, 2006-2010.

	Total GWG. (continuous)			Total Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Demographics							
Age			**p=0.016**				p=0.444
16-19	33.2	(15.5)		29.96%	27.76%	32.28%	
20-24	29.8	(16.2)		44.05%	41.49%	38.25%	
25-29	30.6	(17.6)		15.86%	20.00%	16.89%	
≥30	29.8	(15.9)		10.13%	10.75%	12.58%	
Marital Status			p=0.320				p=0.419
Single/Separated/Divorced/Widowed	31.2	(16.6)		86.67%	87.46%	87.71%	
Married	28.7	(15.3)		10.00%	11.53%	9.91%	
Refused	31.4	(13.8)		3.33%	1.02%	2.39%	
Education			p=0.200				**p=0.003**
less than high school	30	(17.1)		58.57%	47.65%	43.74%	
high school graduate or GED	31.5	(16.4)		29.52%	33.56%	34.30%	
post high school	32.2	(14.4)		11.90%	18.79%	21.96%	
Income			**p=0.030**				p=0.124
≤$15,000	29.1	(15.9)		32.69%	33.11%	28.15%	
>$15,000-$30,000	31.6	(14.8)		9.62%	16.38%	17.55%	
≥$30,000	35.0	(19.3)		5.77%	6.48%	6.76%	
don't know/refuse	31.4	(16.7)		51.92%	44.03%	47.53%	
Number of Adults in Household			p=0.270				p=0.502
1	30.9	(16.8)		26.19%	26.03%	27.37%	
2	30.3	(15.9)		47.14%	52.05%	46.17%	
≥3	32.2	(16.9)		26.67%	21.92%	26.46%	
Number of Children in Household			**p=0.001**				p=0.147
0	34.6	(18.8)		15.53%	17.59%	21.60%	
1	30.7	(15.5)		38.35%	33.45%	38.18%	
2	29.6	(16.0)		25.73%	25.52%	23.28%	
≥3	28.7	(15.4)		20.39%	23.45%	16.95%	
Acculturation			p=0.613				p=0.412
low (1-<3)	30.8	(16.3)		81.28%	76.43%	79.31%	
high (≥3)	31.5	(17.1)		18.72%	23.57%	20.69%	
Generation in US			**p<0.001**				**p=0.018**
born in PR/DR	29.5	(15.3)		50.46%	51.54%	41.91%	
parent born in PR/DR	31.9	(17.1)		45.41%	43.83%	50.60%	
grandparent born in PR/DR	36.6	(15.3)		4.13%	4.63%	7.50%	
Behavioral Characteristics							
Smoking During Early Pregnancy			p=0.058				p=0.425
None	31.8	(15.9)		86.00%	84.16%	88.13%	
≤10 cigs/day	28.7	(17.6)		11.33%	14.36%	10.86%	
>10 cigs/day	22.8	(27.5)		2.67%	1.49%	1.01%	
Alcohol Consumption During Early Pregnancy			**p=0.033**				p=0.069
no	31.0	(16.1)		100.00%	97.54%	96.96%	
yes	39.5	(20.9)		0.00%	2.46%	3.04%	
Probable Major Depression, Early Pregnancy			p=0.308				p=0.076
no	31.5	(16.1)		77.40%	78%	84%	
yes	29.9	(16.6)		22.60%	22%	16%	

Table 2.5b., continued.

	Total GWG. (continuous)			Total Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Probable Major Depression, Mid Pregnancy			p=0.398				p=0.728
no	30.8	(16.9)		79.23%	83%	82%	
yes	29.3	(15.7)		20.77%	17%	18%	
Probable Major Depression, Late Pregnancy			p=0.401				p=0.796
no	31.0	(15.5)		85.04%	87%	87%	
yes	29.6	(14.5)		14.96%	13%	13%	
Anxiety, Early Pregnancy			p=0.003				p=0.018
Mean (SD)	40.1	(10.3)		41.4 (10.3)	41.1 (10.4)	39.1 (10.2)	
Anxiety, Mid Pregnancy			p=0.952				p=0.662
Mean (SD)	33.9	(11.4)		33.1 (10.3)	34.4 (11.9)	34.0 (11.5)	
Anxiety, Late Pregnancy			p=0.066				p=0.468
Mean (SD)	32.8	(11.3)		33.5 (11.7)	33.4 (11.7)	32.4 (10.9)	
Stress, Early Pregnancy			p=0.068				p=0.050
Mean (SD)	26.1	(7.1)		7.0 (7.2)	26.7 (7.0)	25.6 (7.1)	
Stress, Mid Pregnancy			p=0.301				p=0.432
Mean (SD)	25.1	(7.3)		25.7 (6.7)	25.4 (7.4)	24.8 (7.6)	
Stress, Late Pregnancy			p=0.124				p=0.488
Mean (SD)	23.5	(7.7)		24.0 (8.5)	23.9 (7.7)	23.2 (7.5)	
Physical Activity, early pregnancy (METS/wk)			p=0.401				p=0.509
Mean (SD)	188.9	(138.8)		178.7 (161.6)	186.4 (125.8)	194.1 (136.1)	
Physical Activity, mid pregnancy (METS/wk)			p=0.537				p=0.897
Mean (SD)	183.8	(128.6)		188.8 (155.7)	182.6 (127.2)	183.1 (117.6)	
Physical Activity, late pregnancy (METS/wk)			p=0.162				p=0.649
Mean (SD)	165	(98.7)		164.5 (107.5)	171.4 (104.7)	163.0 (92.6)	
Characteristics of Pregnancy							
Morning Sickness in Early Pregnancy			**p=0.012**				**p=0.038**
no	32.8	(16.3)		24.76%	34.75%	33.27%	
yes	30.1	(16.3)		75.24%	65.25%	66.73%	
Infant Birth Weight (grams)			**p<0.001**				**p<0.001**
Mean (SD)	3307.5	(457.3)		3158.2 (410.4)	3218.3 (455.7)	3411.1 (452.8)	
Gesational Age of Infant at Delivery (weeks)			**p<0.001**				**p<0.001**
Mean (SD)	39.6	(1.2)		39.3 (1.1)	39.5 (1.4)	39.7 (1.2)	
Presence of Labor before Cesarean			p=0.713				p=0.950
No Labor	32.1	(17.3)		58.54%	58.73%	60.63%	
Labor	32.9	(17.3)		41.46%	41.27%	39.38%	
Medical History							
Pre-Pregnancy BMI			**p<0.001**				**P<0.001**
<18.5	22.7	(13.7)		8.37%	9.85%	0.00%	
18.5-<25	35.6	(14.4)		50.22%	51.94%	42.90%	
25-<30	31.9	(15.6)		14.10%	17.91%	30.03%	
≥30	23.3	(17.0)		27.31%	20.30%	27.06%	
Gravidity			**p<0.001**				p=0.144
1 total pregnancy	34.1	(16.0)		28.76%	29.55%	35.49%	
2 total pregnancies	30.4	(16.0)		25.22%	24.18%	25.21%	
3+ total pregnancies	29.1	(15.9)		46.02%	31.04%	39.30%	
Parity			**p<0.001**				**p=0.038**
0 live births	34.1	(16.3)		34.80%	38.81%	45.36%	
1 live birth	29.4	(15.8)		33.92%	30.15%	29.64%	
≥2 live births	27.9	(15.9)		31.28%	31.04%	25.00%	

Table 2.5c. Distribution of Covariates According to Rate of GWG: Proyecto Buena Salud, 2006-2010.

	Rate of GWG. (continuous)			Rate of Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Demographics							
Age			**p<0.001**				p=0.086
16-19	1.16	(0.46)		23.66%	31.41%	34.12%	
20-24	1.00	(0.43)		41.94%	41.67%	36.15%	
25-29	0.96	(0.51)		18.28%	18.59%	17.74%	
≥30	0.92	(0.46)		16.13%	8.33%	11.99%	
Marital Status			**p=0.037**				p=0.388
Single/Separated/Divorced/Widowed	1.05	(0.46)		83.91%	87.32%	88.99%	
Married	0.91	(0.47)		13.79%	9.86%	9.33%	
Refused	1.01	(0.48)		2.30%	2.82%	1.68%	
Education			p=0.854				p=0.087
less than high school	1.03	(0.50)		54.60%	47.89%	43.65%	
high school graduate or GED	1.03	(0.44)		31.03%	35.92%	35.17%	
post high school	1.05	(0.42)		14.37%	16.20%	21.18%	
Income			p=0.181				p=0.144
≤$15,000	0.99	(0.46)		38.95%	24.82%	29.80%	
>$15,000-$30,000	1.01	(0.45)		14.53%	15.60%	17.50%	
≥$30,000	1.03	(0.49)		4.65%	5.67%	6.52%	
don't know/refuse	1.07	(0.48)		41.86%	53.90%	46.18%	
Number of Adults in Household			**p=0.035**				p=0.232
1	1.04	(0.50)		24.71%	19.29%	27.37%	
2	1.00	(0.46)		54.02%	53.57%	47.67%	
≥3	1.10	(0.42)		21.26%	27.14%	24.95%	
Number of Children in Household			**p=0.001**				p=0.078
0	1.15	(0.47)		15.70%	14.49%	21.44%	
1	1.02	(0.45)		41.28%	35.51%	38.33%	
2	1.01	(0.45)		20.93%	25.36%	24.29%	
≥3	0.95	(0.48)		22.09%	24.64%	15.94%	
Acculturation			p=0.499				p=0.814
low (1-<3)	1.03	(0.46)		78.44%	80.62%	78.03%	
high (≥3)	1.06	(0.48)		21.56%	19.38%	21.97%	
Generation in US			**p=0.001**				p=0.750
born in PR/DR	0.99	(0.43)		48.57%	48.03%	46.43%	
parent born in PR/DR	1.07	(0.48)		47.43%	44.74%	47.65%	
grandparent born in PR/DR	1.20	(0.53)		4.00%	7.24%	5.91%	
Behavioral Characteristics							
Smoking During Early Pregnancy			**p=0.011**				p=0.157
None	1.06	(0.45)		81.60%	88.57%	88.25%	
≤10 cigs/day	0.91	(0.51)		15.20%	10.48%	11.00%	
>10 cigs/day	0.77	(0.27)		3.20%	0.95%	0.75%	
Alcohol Consumption During Early Pregnancy			**p=0.047**				p=0.231
no	1.03	(0.45)		100.00%	99.03%	97.75%	
yes	1.32	(0.59)		0.00%	0.97%	2.25%	
Probable Major Depression, Early Pregnancy			p=0.601				p=0.380
no	1.04	(0.47)		77.24%	82%	83%	
yes	1.01	(0.40)		22.76%	18%	17%	

Table 2.5c., continued.

	Rate of GWG. (continuous)			Rate of Gestational Weight Gain			
				Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	M	SD	p-value	%	%	%	p-value
Probable Major Depression, Mid Pregnancy			p=0.153				p=0.305
no	1.04	(0.48)		76.15%	84%	82%	
yes	0.96	(0.45)		23.85%	16%	18%	
Probable Major Depression, Late Pregnancy			p=0.344				p=0.372
no	1.03	(0.44)		83.48%	86%	88%	
yes	0.98	(0.44)		16.52%	14%	12%	
Anxiety, Early Pregnancy			**p=0.047**				p=0.117
Mean (SD)	40.1	(10.4)		41.5 (10.5)	40.6 (10.7)	39.5 (10.3)	
Anxiety, Mid Pregnancy			p=0.619				p=0.913
Mean (SD)	34.0	(11.6)		34.4 (11.8)	33.7 (11.1)	33.9 (11.9)	
Anxiety, Late Pregnancy			**p<0.050**				p=0.140
Mean (SD)	33.1	(11.6)		34.9 (12.1)	33.2 (11.3)	32.4 (11.4)	
Stress, Early Pregnancy			p=0.476				p=0.286
Mean (SD)	26.1	(7.2)		26.5 (7.5)	26.8 (7.0)	25.7 (7.1)	
Stress, Mid Pregnancy			p=0.571				p=0.240
Mean (SD)	25.1	(7.5)		26.0 (7.6)	28.6 (7.0)	24.7 (7.6)	
Stress, Late Pregnancy			p=0.190				p=0.308
Mean (SD)	23.8	(7.8)		24.6 (8.7)	24.2 (7.7)	23.4 (7.5)	
Physical Activity, early pregnancy (METS/wk)			p=0.424				p=0.169
Mean (SD)	185.0	(137.5)		167.0 (112.6)	176.8 (115.4)	192.7 (149.3)	
Physical Activity, mid pregnancy (METS/wk)			p=0.425				p=0.684
Mean (SD)	183.8	(127.3)		190.2 (128.5)	189.0 (163.9)	179.4 (115.1)	
Physical Activity, late pregnancy (METS/wk)			p=0.549				p=0.901
Mean (SD)	168.7	(102.2)		171.8 (117.4)	169.5 (93.3)	167.9 (99.2)	
Characteristics of Pregnancy							
Morning Sickness in Early Pregnancy			**p=0.022**				p=0.058
no	1.09	(0.47)		24.71%	37.06%	30.04%	
yes	1.01	(0.46)		75.29%	62.94%	69.96%	
Infant Birth Weight (grams)			**p<0.001**				**P<0.001**
Mean (SD)	3318.4	(446.2)		3182.3 (383.1)	3238.1 (502.9)	3382.2 (437.1)	
Gesational Age of Infant at Delivery (weeks)			**p=0.001**				**P=0.005**
Mean (SD)	39.70	(1.1)		39.5 (1.0)	39.6 (1.2)	39.7 (1.1)	
Presence of Labor before Cesarean			p=0.257				p=0.923
No Labor	1.03	(0.49)		58.82%	62.07%	62.50%	
Labor	1.11	(0.53)		41.18%	37.93%	37.50%	
Medical History							
Pre-Pregnancy BMI			**p<0.001**				**P<0.001**
<18.5	1.09	(0.32)		8.37%	9.85%	0.00%	
18.5-<25	1.16	(0.42)		50.22%	51.94%	42.90%	
25-<30	1.03	(0.44)		14.10%	17.91%	30.03%	
≥30	0.80	(0.50)		27.31%	20.30%	27.06%	
Gravidity			**p<0.001**				**p=0.004**
1 total pregnancy	1.17	(0.46)		21.51%	35.90%	36.33%	
2 total pregnancies	1.01	(0.47)		28.49%	20.51%	24.11%	
3+ total pregnancies	0.94	(0.45)		50.00%	43.59%	39.56%	
Parity			**p<0.001**				**p<0.001**
0 live births	1.17	(0.46)		26.88%	41.03%	47.29%	
1 live birth	0.98	(0.46)		40.86%	25.64%	30.00%	
≥2 live births	0.88	(0.43)		32.26%	33.33%	22.71%	

Table 2.6. Distribution of Covariates According to Mode of Delivery: Proyecto Buena Salud, 2006-2010.

	Mode of Delivery		
	Vaginal	Cesarean	
	%	%	p-value
Demographics			
Age			**p<0.001**
16-19	33.44%	20.58%	
20-24	41.45%	36.10%	
25-29	15.92%	22.74%	
≥30	9.19%	20.58%	
Marital Status			p=0.978
Single/Separated/Divorced/Widowed	87.57%	87.35%	
Married	10.27%	10.28%	
Refused	2.15%	2.37%	
Education			p=0.487
less than high school	48.29%	47.04%	
high school graduate or GED	33.29%	31.23%	
post high school	18.42%	21.74%	
Income			p=0.567
≤$15,000	29.70%	33.60%	
>$15,000-$30,000	15.09%	16.21%	
≥$30,000	6.59%	5.93%	
don't know/refuse	48.62%	44.27%	
Number of Adults in Household			p=0.228
0	25.78%	28.57%	
1	47.49%	50.00%	
2	26.73%	21.43%	
≥3			
Number of Children in Household			p=0.974
0	19.39%	19.76%	
1	36.36%	36.69%	
2	24.36%	25.00%	
≥3	19.88%	18.55%	
Acculturation			p=0.126
low (1-<3)	79.80%	75.21%	
high (≥3)	20.20%	24.79%	
Generation in US			p=0.139
born in PR/DR	45.67%	48.47%	
parent born in PR/DR	47.65%	48.09%	
grandparent born in PR/DR	6.68%	3.44%	
Behavioral Characteristics			
Smoking During Early Pregnancy			p=0.887
None	86.60%	86.21%	
≤10 cigs/day	12.06%	12.07%	
>10 cigs/day	1.34%	1.72%	
Alcohol Consumption During Early Pregnancy			p=0.776
no	97.48%	98.26%	
yes	2.52%	1.74%	
Probable Major Depression, Early Pregnancy			p=0.776
no	81.82%	79.17%	
yes	18.18%	20.83%	

Table 2.6., continued.

	Mode of Delivery		
	Vaginal	Cesarean	
	%	%	p-value
Probable Major Depression, Mid Pregnancy			p=0.189
no	82.63%	78.05%	
yes	17.37%	21.95%	
Probable Major Depression, Late Pregnancy			p=0.336
no	87.57%	84.62%	
yes	12.43%	15.38%	
Anxiety, Early Pregnancy			p=0.972
Mean (SD)	40.2 (10.4)	40.2 (10.3)	
Anxiety, Mid Pregnancy			p=0.380
Mean (SD)	33.7 (11.4)	34.8 (11.7)	
Anxiety, Late Pregnancy			p=0.210
Mean (SD)	32.6 (11.0)	33.8 (11.8)	
Stress, Early Pregnancy			p=0.552
Mean (SD)	26.2 (7.2)	25.9 (7.0)	
Stress, Mid Pregnancy			p=0.375
Mean (SD)	25.0 (7.4)	25.6 (7.0)	
Stress, Late Pregnancy			p=0.445
Mean (SD)	23.4 (7.6)	23.9 (8.0)	
Physical Activity, early pregnancy (METS/wk)			p=0.908
Mean (SD)	188.3 (142.1)	186.9 (124.0)	
Physical Activity, mid pregnancy (METS/wk)			p=0.687
Mean (SD)	182.4 (122.9)	187.2 (142.1)	
Physical Activity, late pregnancy (METS/wk)			p=0.577
Mean (SD)	162.6 (93.5)	167.8 (113.9)	
Characteristics of Pregnancy			
Morning Sickness in Early Pregnancy			p=0.448
no	33.10%	30.56%	
yes	66.90%	69.44%	
Infant Birth Weight			**p=0.033**
Mean (SD)	3291.6 (421.7)	3358.3 (554.4)	
Gesational Age of Infant at Delivery			**p=0.033**
Mean (SD)	39.6 (1.3)	39.4 (1.5)	
Medical History			
Pre-Pregnancy BMI			**p<0.001**
<18.5	6.65%	3.25%	
18.5-<25	48.55%	36.82%	
25-<30	23.58%	22.74%	
≥30	21.22%	37.18%	
Gravidity			**p=0.042**
1 total pregnancy	33.73%	27.17%	
2 total pregnancies	25.16%	23.55%	
3+ total pregnancies	41.11%	49.28%	
Parity			p=0.600
0 live births	42.09%	38.77%	
1 live birth	30.02%	31.16%	
≥2 live births	27.88%	30.07%	

Table 2.7. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for Gestational Weight Gain and Cesarean Delivery: Proyecto Buena Salud, 2006-2010.

	Risk of Cesarean Delivery					
	Unadjusted			Adjusting for age and pre-pregnancy BMI		
	N	RR	95% CI	N	RR	95% CI
Gestational Weight Gain During 1st Trimester (lbs)	944			941		
		1.01	(1.00, 1.01)		1.01	(1.00, 1.01)
Total Gestational Weight Gain (lbs)	1188			1182		
		1.01	(1.00, 1.02)		**1.02**	**(1.01, 1.02)**
Adherence to IOM Guidelines for Total Weight Gain	1168			1166		
Inadequate Gestational Weight Gain		0.98	(0.79, 1.19)		0.90	(0.61, 1.30)
Within Guidelines		1.0	Referent		1.00	Referent
Excessive Gestational Weight Gain		**1.41**	**(1.10, 1.78)**		**1.15**	**(1.05, 1.73)**
Rate of Gestational Weight Gain (lbs/week)	936			934		
		1.22	(0.93, 1.55)		**1.82**	**(1.42, 2.27)**
Rate of Gestational Weight Gain (STANDARDIZED)	936			934		
		1.1	(0.97, 1.24)		**1.34**	**(1.19, 1.52)**
Adherence to IOM Guidelines for Rate of Weight Gain	934			934		
Inadequate Gestational Weight Gain		1.02	(0.64, 1.53)		0.74	(0.44, 1.19)
Within Guidelines		1.0	Referent		1.0	Referent
Excessive Gestational Weight Gain		1.39	(0.98, 1.89)		1.27	(0.88, 1.77)

Table 2.8. Adjusted Relative Risks and 95% Confidence Intervals for Gestational Weight Gain and Cesarean Delivery Among Women with Labor Before Cesarean: Proyecto Buena Salud, 2006-2010.

	Risk of Cesarean Delivery with Labor Before Cesarean		
		Adjusted for age and pre-pregnancy BMI	
	N	RR	95% CI
Gestational Weight Gain During 1st Trimester (lbs)	859		
		1.01	(0.99, 1.03)
Total Gestational Weight Gain (lbs)	1076		
		1.02	**(1.01, 1.02)**
Adherence to IOM Guidelines for Total Weight Gain	1060		
Inadequate Gestational Weight Gain		0.89	(0.55, 1.39)
Within Guidelines		1.00	Referent
Excessive Gestational Weight Gain		1.37	(1.00, 1.84)
Rate of Gestational Weight Gain (lbs/week)	852		
		1.89	**(1.42, 2.43)**
Rate of Gestational Weight Gain (STANDARDIZED)	852		
		1.37	**(1.19, 1.58)**
Adherence to IOM Guidelines for Rate of Weight Gain	852		
Inadequate Gestational Weight Gain		0.77	(0.41, 1.35)
Within Guidelines		1.0	Referent
Excessive Gestational Weight Gain		1.30	(0.83, 1.91)

Table 2.9. Adjusted Relative Risks and 95% Confidence Intervals for Gestational Weight Gain and Cesarean Delivery Stratified by Parity: Proyecto Buena Salud, 2006-2010.

	Risk of Cesarean Delivery, Nulliparous			Risk of Cesarean Delivery, Parous		
	Adjusted for age and pre-pregnancy BMI			Adjusted for age and pre-pregnancy BMI		
	N	RR	95% CI	N	RR	95% CI
Gestational Weight Gain During 1st Trimester (lbs)	394			545		
		1.00	(0.98, 1.03)		1.02	(0.99, 1.03)
Total Gestational Weight Gain (lbs)	490			690		
		1.01	(1.00, 1.02)		**1.02**	**(1.01, 1.02)**
Adherence to IOM Guidelines for Total Weight Gain	482			682		
Inadequate Gestational Weight Gain		0.69	(0.32, 1.34)		1.04	(0.65, 1.58)
Within Guidelines		1.00	Referent		1.00	Referent
Excessive Gestational Weight Gain		1.30	(0.84, 1.91)		1.18	(0.95, 1.83)
Rate of Gestational Weight Gain (lbs/week)	393			539		
		1.80	**(1.22, 2.50)**		**1.75**	**(1.23, 2.36)**
Rate of Gestational Weight Gain (STANDARDIZED)	393			539		
		1.34	**(1.10, 1.61)**		**1.32**	**(1.10, 1.55)**
Adherence to IOM Guidelines for Rate of Weight Gain	393			539		
Inadequate Gestational Weight Gain		0.48	(0.16, 1.27)		0.88	(0.47, 1.53)
Within Guidelines		1.0	Referent		1.0	Referent
Excessive Gestational Weight Gain		1.14	(0.63, 1.91)		1.32	(0.80, 1.99)

CHAPTER 3

GESTATIONAL WEIGHT GAIN AND RISK OF GESTATIONAL DIABETES MELLITUS AMONG HISPANIC WOMEN

Abstract

Gestational diabetes mellitus (GDM) affects 1-20% of all pregnancies in the United States, depending on population and diagnostic criteria. The prevalence of GDM among Hispanic women is up to twice as high as among non-Hispanic white women. Both inadequate and excessive gestational weight gain (GWG) are associated with poor maternal and infant outcomes. More than half of pregnant women do not gain weight within Institute of Medicine (IOM) guidelines, and excessive GWG is more common among Hispanic women than non-Hispanic white women. Prior research indicates that GWG may be associated with GDM, however findings have been conflicting due, in part, to the wide variability in the measurement of GWG. Therefore, we investigated the association between GWG (GWG in the 1st trimester, GWG until GDM screen, rate of GWG until GDM screen and total GWG) and abnormal glucose tolerance (AGT) and GDM in Proyecto Buena Salud (PBS), a prospective cohort study of 1,583 Hispanic pregnant women aged 16-40 years. GWG, AGT and GDM were abstracted from medical records. Multivariable logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI), adjusting for age and pre-pregnancy body mass index (BMI). Women gained an average of 31 lbs during pregnancy (SD=16 lbs). More than half (51%) of women exceeded and 20% of women gained less than IOM recommendations for total GWG. The prevalence of GDM was 4.5%, and 10% of women had AGT. After adjusting for age and pre-pregnancy BMI, GWG in the 1st trimester and total GWG were

not associated with AGT nor GDM. However, rate of GWG from the end of the first trimester until GDM screen was associated with a lower risk of AGT (RR=0.68, 95% CI 0.51-0.92) but not with GDM. When examining adherence to IOM guidelines, excessive GWG until the GDM screen and excessive total GWG were associated with a lower risk of AGT, compared to women gaining within IOM guidelines (RR=0.65, 95% CI 0.42-0.99 and RR=0.62, 95% CI 0.42-0.92, respectively), but not with GDM. Results were unchanged when the sample was restricted to nulliparous women. After stratifying by pre-pregnancy BMI, the lower risk of AGT was primarily found among women who had a normal BMI before pregnancy. Findings suggest that GWG may be associated with a lower risk of AGT among Hispanic women who have a normal BMI before pregnancy, but future studies are needed to further elucidate this association.

Introduction

The prevalence of gestational diabetes mellitus (GDM) in the US has increased over the past few decades. GDM is diagnosed in 1-20% of all pregnancies in the United States (100–102) and the rate varies by race and ethnicity. African American, Hispanic and Asian women have up to twice the risk of GDM compared with non-Hispanic white women (102). Milder glucose intolerance (such as abnormal glucose tolerance, AGT) is even more prevalent than GDM (100,102).

Maternal consequences of GDM include increased risk of preeclampsia (103–105), cesarean delivery (105) and up to seven times the risk of type 2 diabetes within a decade of the index pregnancy (106,107). Fetal consequences include large-for-gestational age infants (108), macrosomia (103,104,108), hypoglycemia (105,108), shoulder dystocia (103,105) perinatal death (104), and long-term consequences in regards

to obesity and glucose tolerance (109). Evidence suggests that these consequences are not associated with a particular threshold of glucose intolerance, but rather that there is a dose-response association between glucose intolerance and maternal and fetal morbidity (100,110–113). Risk factors for GDM include advanced maternal age (114–116), maternal pre-pregnancy overweight and obesity (114–117), history of GDM (114,115), family history of diabetes (116), increasing parity (116), and inactivity (115).

Prior research indicates that inadequate and excessive GWG, as recommended by the Institute of Medicine's (IOM) 2009 guidelines according to pre-pregnancy BMI, is associated with poor maternal and fetal outcomes. Most women do not gain within IOM recommendations with as many as 70% of women gaining more or less than recommended depending on the population studied (2,8). Women who are overweight or obese before pregnancy are more likely to gain excessive weight during pregnancy, compared to women who have normal pre-pregnancy BMI (1). Close to 52% of Hispanic women are overweight or obese at the start of their pregnancy as compared to 44% of non-Hispanic white women (10–13), making Hispanic women at particularly high risk of excessive GWG.

GWG, and associated excess adipose tissue, may lead to AGT and GDM through four distinct mechanisms: increased levels of adipokines, increased ectopic fat deposits, excessive nutrient concentration at the cellular level, and high iron levels and vitamin D deficiency.

In the past 10 years, 29 epidemiological studies examining the association between GWG and GDM have been published. Prior studies have observed conflicting findings, with some studies reporting a positive association between GWG and AGT /

GDM (77,118–127), and some studies reporting a negative association (84,128–135). There is wide variability in the definition of GWG and most studies used only total GWG, a measure that is likely influenced by diagnosis of GDM in mid-pregnancy. The majority of studies were limited to non-Hispanic white women.

Therefore, we investigated the association between GWG measured in several ways (GWG in the 1st trimester, GWG until GDM screen, rate of GWG until GDM screen and total GWG) and AGT and GDM using data from Proyecto Buena Salud, a prospective cohort study of 1,583 Hispanic pregnant women.

Physiology

Excessive GWG and excess adipose tissue may lead to AGT and GDM through four distinct mechanisms, although the pathways are not mutually exclusive and most likely have significant overlap: 1) increased levels of adipokines, 2) increased ectopic fat deposits, 3) excessive nutrient concentration at the cellular level, and 4) high iron levels and vitamin D deficiency. Typical GWG is comprised of approximately 30% adipose tissue (136). However, that proportion is increased among women with excessive GWG and may depend on when weight is gained during pregnancy. For example, weight gained in the first trimester (before 13 weeks gestation) has a larger proportion of adipose tissue than weight gained during the final weeks of pregnancy, when fetal growth is rapid (1). Increased adipose tissue is associated with insulin resistance and therefore diabetes, depending on the degree of obesity and where the adipose tissue accumulates. Visceral adiposity (adipose tissue accumulated as abdominal girth) in particular is associated with metabolic syndrome and an increased risk of type 2 diabetes (137).

First, the adipose tissue accumulated during pregnancy functions not only as storage of excess caloric energy, but has recently been recognized to also serve as a distinct endocrine organ producing pro-inflammatory adipokines (137,138). In addition, the excess adipose tissue disrupts the balance of pro-inflammatory adipokines and anti-inflammatory adipokines by switching some anti-inflammatory cells to pro-inflammatory cells (138). Excess GWG, therefore, increases the production of pro-inflammatory adipokines, contributing to chronic inflammation and interfering with insulin sensitivity.

Secondly, increased ectopic adipose tissue (adipose tissue collecting in non-typical locations throughout the body such as the liver, muscles and in the abdominal cavity, known as visceral fat), leads to insulin resistance through disruption of metabolic processes and impaired organ function (137,139). Therefore, excessive and/or rapid GWG may exceed the storage capacity of peripheral adipose tissue storage and increase ectopic adipose tissue, leading to insulin resistance and hyperinsulinemia.

Thirdly, excessive energy consumption may lead to excessive nutrient concentrations at the cellular level. When cells are exposed to excessive nutrient concentrations, impaired inflammatory signaling may result, including mitochondrial dysfunction and increased levels of reactive oxygen species, leading to inefficient glucose and lipid metabolism, cell damage and oxidative stress (140,141) and disruption to insulin signaling pathways (142). Therefore, excess nutrient concentration can escalate pro-inflammatory pathways, leading to insulin resistance and glucose dysregulation (137).

Finally, recent research has found that excess energy consumption is associated with abnormal micronutrient levels that may contribute to insulin resistance, particularly

iron and vitamin D. Overweight and obesity are associated with high iron levels (143) and, in turn, high iron levels are associated with changes in glucose metabolism (144,145). In animal models, excess iron has been shown to induce diabetes (146). Furthermore, diabetes can be prevented with iron binding medication among those with excess iron (such as hereditary hemochromatosis) (147). Studies have found that women diagnosed with GDM have higher iron stores (148–150). Excess energy consumption and obesity is also, conversely, associated with vitamin D deficiency (151–153). Vitamin D is involved in glucose regulation (154). Research has found a consistent link between vitamin D deficiency and type 2 diabetes (155,156), and between vitamin D deficiency and GDM (99,153,157). Therefore, excessive energy consumption during pregnancy and consequentially, excessive GWG, may lead to elevated iron concentrations and vitamin D deficiency, both of which are associated with insulin resistance.

Epidemiology

In the last decade, 28 epidemiological studies have examined the association between GWG and impaired glucose tolerance (IGT), AGT and/or GDM. Of these, 11 found a positive association between GWG and IGT / AGT / GDM (77,118–127), 9 found an inverse association between GWG and IGT / AGT / GDM (84,128–135), and 8 found no association (76,88,158–163). Across these studies, GWG was measured in different ways, including categories based on the 1990 IOM guidelines (76,128), the 2009 IOM guidelines (118,123,127,130–132,134,135,162,163), quartiles (77,125), continuous GWG only (119,133,161) and other author-selected categories of GWG (84,88,120–122,124,126,129,159,160). Most of the studies included only total GWG (76,77,84,88,124,127,130,132,135,161–163). Some studies were able to measure GWG

until various points throughout pregnancy, including GWG in the first trimester (119), GWG until 15-18 weeks gestation (120)GWG until the end of the 2nd trimester (~26 weeks gestation) (121,128), GWG until the glucose screening (typically 24-28 weeks gestation) (122,123,129,133,158), GWG up to 28 weeks gestation (125,134), GWG up to 30 weeks gestation (131), and rate of GWG (118,122,126,129,159,160).

Variability in measurement and categorization of GWG may contribute, in part, to the conflicted findings. Total GWG may be a biased measure due to its inherent correlation with length of gestation, which is an established risk factor for various adverse birth outcomes including low birth weight or macrosomia, neonatal respiratory distress and stillbirth (79). Further, total GWG includes weight gain which occurs after GDM diagnosis. This post-diagnosis weight gain may be influenced by the disease itself as well as by its management and treatment. Therefore, the temporality of the association between GWG and GDM cannot be assessed with this GWG measure.

Nearly all of the studies were cohort designs, half of which were prospective (88,120–123,125,128–131,134,159,163) and half of which were retrospective (76,77,84,119,127,132,133,135,158,160–162). The remaining studies were case-control (118,126) or cross-sectional studies (124). The vast majority (24) of the studies only considered GDM as an outcome (77,84,88,118–121,124–128,130–135,158–163). One study included both AGT and GDM (123), two studies included IGT and GDM (76,122), and one study only considered AGT (129). Finally, less than half of the studies (8) included Hispanic participants (84,118–120,122,129,133,161), but only 1 study was conducted in an entirely Hispanic sample (129). Most studies (20) did not include any Hispanic women (76,77,88,121,123–128,130–132,134,135,158–160,162,163).

In a recent study examining early GWG (i.e,, prior to diagnosis of GDM), Carreno et al.(120) prospectively studied 7,985 women (~30% Hispanic) in the United States who delivered a live infant without fetal congenital malformations after 20 weeks gestation between 2003-2008. The participants were recruited for a randomized controlled trial testing the effectiveness of vitamins C and E in preventing complications of gestational hypertension. Pre-pregnancy weight was self-reported and weight at a prenatal visit between 15 and 18 weeks gestation was abstracted from medical records.

After adjusting for maternal age, smoking status, race and treatment group, the authors found that excessive early GWG, according to 2009 IOM guidelines, was associated with a 40% higher risk of GDM compared to non-excessive early GWG (OR=1.4, 95% CI 1.1-1.9). The risk was higher among women with normal pre-pregnancy BMI, (OR=1.7, 95% CI 1.1-2.7) than women who were overweight or obese before pregnancy (OR=1.6, 95% CI 1.0-2.6, and OR=1.3, 95% CI .8-1.9, respectively) (120). While the study included Hispanic participants, it did not conduct a separate analysis limited to Hispanic women. In addition, weight gain to 15-18 weeks gestation was used as the only measure of "early" GWG, as opposed to GWG up to the time of GDM screen.

Hypotheses

Specific Aim 1: To evaluate the association between GWG and risk of AGT and GDM in a population of Hispanic women.

Hypothesis 1a: GWG in the first trimester is positively associated with AGT and GDM.

Hypothesis 1b: Excessive rate of GWG from end of the first trimester until the GDM screen, according to IOM guidelines, is associated with increased risk of AGT and GDM, compared to rate of GWG within guidelines.

Hypothesis 1c: Excessive GWG until GDM screen, according to IOM guidelines, is associated with increased risk of AGT and GDM, compared to GWG within guidelines.

Hypothesis 1d: Excessive total GWG, according to IOM guidelines, is associated with increased risk of AGT and GDM, compared to total GWG within guidelines.

Methods

Study Design

We examined the association between GWG and AGT, and GWG and GDM using data from Proyecto Buena Salud (PBS), a prospective cohort study of Hispanic prenatal care patients at Baystate Medical Center in Springfield, Massachusetts from January 2006 through October 2010. Bilingual interviewers (Spanish and English) recruited patients at a prenatal care visit early in pregnancy (before 20 weeks gestation). Pregnant women were informed regarding the aims and procedures of the study and provided written informed consent approved by the Institutional Review Boards of the University of Massachusetts Amherst and Baystate Medical Center. The study consisted of three structured interviews, conducted in Spanish or English (based on the participant's preference) as well as medical record review. The first interview (early pregnancy) occurred at the time of enrollment (between 6 and 18 weeks gestation). The second (mid-pregnancy) interview occurred between 18.1 and 26 weeks gestation.

Because the final (late pregnancy) interview occurred after GDM screening (between 26.1 and 43 weeks gestation), it was not considered in this prospective analysis (Figure 1). Medical records were abstracted after delivery for clinical characteristics of the current pregnancy and medical and obstetrical history.

Study Population

Women were eligible to participate in PBS if they were of Puerto Rican or Dominican Republic heritage, defined as having been born in the Caribbean Islands, having a parent who was born in the Caribbean Islands or having two grandparents who were born in the Caribbean Islands. Exclusion criteria included 1) taking medications thought to adversely influence glucose tolerance, 2) multiple gestation, 3) history of diabetes, hypertension, heart disease or chronic renal disease and 4) <16 or >40 years of age at enrollment. Women were excluded from this analysis if information on pre-pregnancy weight or glucose screening was missing, or if they had a spontaneous or therapeutic abortion or a stillbirth before GDM screening.

Exposure Assessment

A clinical weight was recorded for participants at each prenatal care visit during their pregnancy and at the time of delivery. The measured weights and the corresponding gestational age at which the weights were measured were abstracted from medical records.

GWG in the first trimester was calculated as the difference between weight at 13 weeks gestation (abstracted from medical records) and pre-pregnancy weight as self-reported in the first prenatal visit. When pre-pregnancy weight was not available from medical records, self-reported pre-pregnancy weight from the interview in early

pregnancy was used. If no weight was available at 13 weeks gestation, linear interpolation was used to calculate the weight at 13 weeks. Linear interpolation is an method of imputing values within a range of values in a time series (164). Given that each participant has multiple values of measured weights over their pregnancy, and that weight gain is assumed to be linear for most of pregnancy gain (1), linear interpolation is an acceptable method of imputing missing weight at a specific time point within this time series (122). GWG in the first trimester was analyzed as a continuous variable (Table 3.1).

GWG is assumed to be minimal in the first trimester (2.2 – 4.4 lbs) and linear in the second and third trimesters (1). Therefore, rate of GWG after the first trimester until GDM screening was calculated as the difference between weight at screening (abstracted from medical record) and weight at the 13 weeks gestation (abstracted from medical records), divided by weeks of gestation within that time period (Table 3.1). Similarly to the process described above for getting the weight at 13 weeks gestation, if a weight was not available for the week glucose screening occurred, linear interpolation was used to calculate the weight. Rate of GWG after the first trimester until GDM screen was analyzed continuously and additionally, was categorized according to IOM guidelines: inadequate, within, and excessive (Table 3.1). After the first trimester, women with a BMI <18.5 kg/m^2 are advised to gain 1.0-1.3 lbs per week, women with a BMI of 18.5-24.9 kg/m^2 are advised to gain 0.8-1.0 lbs per week, women with a BMI of 25.0-29.9 kg/m^2 are advised to gain 0.5-0.7 lbs per week, and women with a BMI ≥30.0 kg/m^2 are advised to gain 0.4-0.6 lbs per week (Table 1.2) (1).

GWG until GDM screening was calculated as the difference between weight at screening and pre-pregnancy weight. Linear interpolation was used, as described above, if weight at glucose screen was not available. GWG until GDM screen was analyzed as a continuous variable and was additionally categorized according to IOM guidelines. A target range of GWG at the time of screening was calculated for each participant based on IOM weight gain guidelines in the first trimester (2.2 – 4.4 lbs) (1) and IOM guidelines for rate of GWG per week after the first trimester, as others have done (128,129) . Each woman's actual weight gain at the time of screening was then be compared to her target range of weight gain, and categorized as inadequate, within or excessive (Table 3.1).

Total GWG was calculated as the difference between measured maternal weight at delivery (abstracted from medical records) and pre-pregnancy weight. Total GWG was analyzed continuously and was additionally categorized according to IOM guidelines: inadequate (gaining less than the recommended minimum), within (gaining within the recommendation), and excessive (gaining more than the recommended maximum) (Table 3.1). IOM guidelines vary according to pre-pregnancy BMI. Women with a BMI <18.5 kg/m^2 are advised to gain 28-40 lbs, women with a BMI of 18.5-24.9 kg/m^2 are advised to gain 25-35 lbs, women with a BMI of 25.0-29.9 kg/m^2 are advised to gain 15-25 lbs, and women with a BMI ≥30.0 kg/m^2 are advised to gain 11-20 lbs (Table 1.2) (1).

Data on delivery weight was abstracted from medical records by a trained abstractor, as is considered the "gold standard (1)." Pre-pregnancy weight (self-reported at the first prenatal care visit) was also abstracted from medical records after delivery. Self-reported pre-pregnancy weight is commonly used in epidemiologic studies of GWG

because preconception weight measures typically do not exist in obstetrical medical record data. The IOM presents this approach as a practical method for measuring pre-pregnancy weight (1). Prior studies have found that self-reported pre-pregnancy weight is highly correlated with measured pre-pregnancy weight (for example, prior studies have found r=0.95, r=0.98) and that self-reported pre-pregnancy weight is underreported by somewhere between 0.27 to 1.0 kg on average (50–52,165), indicating that GWG would be overestimated. Further, BMI calculated from self-reported weight and measured weight had good agreement (74.5% overall; 76.4% for underweight, 85.3% for normal weight, 75.7% for overweight, 71.9% for obese and 93.1% for severely obese) (53,165).

Outcome Assessment

Glucose values from the 1-hour oral glucose tolerance test (OGTT) and 3-hour OGTT were abstracted from medical records. AGT was defined as an elevated value (>135 mg/dL) on the 1-hour GTT, or any elevated value on the 3-hour OGTT (according to the Carpenter and Coustan criteria) (166) and was analyzed as a dichotomous variable (yes or no) (Table 3.1).

Diagnosis of GDM was abstracted from medical records after delivery, and was analyzed as a dichotomous variable (GDM – yes or no) (Table 3.1). All suspected cases of GDM (based on abstracted diagnosis or elevated values on the 3-hour OGTT) were reviewed by the study physician for confirmation of diagnosis.

Data on glucose values and GDM diagnosis was abstracted from medical records by a trained abstractor, and is considered the "gold standard." All previous epidemiological studies examining the association between GWG and AGT or GDM use

medical record abstraction to collect information on diagnosis (76,77,84,118–122,125,128,129,131,133,134,158,159,167–169).

Covariate Assessment

Marital status, number of adults and children in the household, smoking during early pregnancy, alcohol consumption, morning sickness, education, income, stress (measured via the Perceived Stress Scale) (41), anxiety (measured via the State-Trait Anxiety Inventory) (45), depression (measured via the Edinburgh Depression Scale) (56), physical activity (measured via the Pregnancy Physical Activity Questionnaire) (54) (MET hrs/week) (170), total energy intake (measured via 24-hour diet recalls), acculturation (measured via the Psychological Acculturation Scale) (57), and generation in the United States were obtained through the early pregnancy interview (Table 3.1). Stress, anxiety, depression and physical activity were updated in mid-pregnancy. Gravidity, parity, age, pre-pregnancy BMI, history of GDM and history of macrosomic infants were abstracted from medical records (Table 3.1). Covariates were selected based on inclusion in prior literature (118–122,129,131,158,168,169) and potential for confounding, as assessed through use of directed acyclic graphs.

Data Analysis

To address specific aim 1, we calculated the number and percent of participants in the study sample, the distribution of GWG variables (GWG in the first trimester, Rate of GWG from first trimester until GDM screen, GWG until GDM screen and total GWG) (Table 3.3), and the distribution of AGT and GDM.

Potential confounders were assessed by cross-tabulating covariates by each GWG variable and by AGT and GDM. Pearson chi-square tests for categorical variables, Mantel–Haenszel chi-square tests for ordinal variables, and t-tests for continuous variables were used, and associated p-values are reported. Fisher's Exact Test was used in the case of small cell sizes.

Unadjusted logistic regression was used to model the association between each of the GWG variables and AGT / GDM. Relative risks and 95% confidence intervals are reported.

The final models were developed using multivariable logistic regression models, adjusting for important covariates and confounders (as outlined previously) and retained covariates causing a 10% or greater change in estimate. Relative risks and 95% confidence intervals are reported. All analyses were complete case analyses.

Final models were re-run restricting the sample to only nulliparous women to address potential confounding by short intervals between pregnancies, as prior studies have done (120). We also stratified the final models by pre-pregnancy BMI, as others have done (76,129,163).

Results

A total of 1,583 participants were recruited into PBS. The final sample for analysis included 1,277 Hispanic women, after removing 37 women who were missing information on pre-pregnancy weight, 65 women who had a spontaneous or therapeutic abortion, and 204 women missing glucose screening information (Table 3.2).

The average GWG in the first trimester was 4.8 lbs (SD=8.3 lbs). The average rate of GWG from the end of the first trimester until the GDM screen was 1.0 lbs per

week (SD=0.6 lbs). More than half of women had an excessive rate of GWG from the end of the first trimester until the GDM screen (59.2%). Women's GWG until GDM screen was on average 19.2 lbs (SD=13.4 lbs). More than half of woman had excessive GWG until GDM screen (59.6%). Average total GWG was 30.7 lbs (SD=16.0 lbs) and just over half of women had excessive total GWG (51.0%) (Table 3.3). 20% of the sample had a weight based on linear interpolation.

Of the 1,277 women in the sample, 182 women had AGT during their pregnancy (14.3%). Just over 4.5% of the sample was diagnosed with GDM (57 women) (Table 3.4).

We evaluated participant characteristics according to each GWG variable: GWG in the first trimester (Table 3.5a), rate of GWG after the first trimester until GDM screen (Table 3.5b), GWG until GDM screen (Table 3.5c) and total GWG (Table 3.5d). Pre-pregnancy BMI was positively associated with all GWG variables. Age, education, income, anxiety, not having had morning sickness in early pregnancy, gravidity, parity and history of having a macrosomic infant were all associated with GWG in the first trimester (Table 3.5a). Only greater income and not having had morning sickness were positively associated with rate GWG from the end of the first trimester until the GDM screen (Table 3.5b). Having a higher level of education, being 2nd generation in the US and not experiencing morning sickness in early pregnancy were positively associated with GWG until GDM screen and total GWG (Table 3.5c). Having a higher level of education, being 2nd generation in the US and consuming alcohol during early pregnancy were positively associated with total GWG (Table 3.5d).

We also evaluated participant characteristics according to AGT and diagnosis of GDM (Table 3.6). Increasing age, pre-pregnancy BMI, being married, lower level of education, being 1st generation to the US, parity and having history of GDM diagnosis were positively associated with AGT and GDM. In addition, income between $15,000 and $30,000 per year was positively associated with GDM, but not AGT.

After adjusting for age and pre-pregnancy BMI, increasing GWG in the first trimester was not significantly associated with the risk of AGT (RR=1.00, 95% CI 0.98-1.02) or the risk of GDM (RR=1.01, 95% CI 0.98-1.05) (Table 3.7). However, increasing rate of GWG from the end of the first trimester until the GDM screen was associated with AGT (Table 3.7) with each additional pound of GWG per week associated with a 32% lower risk of AGT (RR=0.68, 95% CI 0.51-0.92), but not with GDM (RR=0.82, 95% CI 0.50-1.37) after adjusting for age and pre-pregnancy BMI. We found no association between adherence to IOM guidelines for rate of GWG from the first trimester until GDM screen and risk of AGT or GDM.

After adjusting for age and pre-pregnancy BMI, GWG until the GDM screen was not associated with AGT (RR=0.99, 95% CI 0.98-1.00) or GDM (RR=1.00, 95% CI 0.98-1.02) (Table 3.7). We found no association between GWG until GDM screen and risk of GDM, and no association between adherence to IOM guidelines for GWG until GDM screen and risk of AGT or GDM.

After adjusting for age and pre-pregnancy BMI, total GWG was not associated with risk of AGT (RR=0.99, 95% CI 0.98-1.00) nor risk of GDM (RR=0.99, 95% CI 0.97-1.01) (Table 3.7). In regards to adherence to IOM guidelines for total GWG, women with excessive total GWG had a 38% lower risk of AGT (RR=0.62, 95% CI 0.42-0.92)

after, adjusting for age and pre-pregnancy BMI. No association was found between adherence to IOM guidelines for total GWG and risk of GDM.

We then conducted a sensitivity analysis, restricting the sample to nulliparous women (Table 3.8). Our results were similar to the results found in the full sample. Among nulliparous women, each additional pound of GWG per week from the end of the first trimester until the GDM screen remained associated with a 39% lower risk of AGT (RR=0.61, 95% CI 0.38-0.96), after adjusting for age and pre-pregnancy BMI. There remained no association between rate of GWG from the end of the first trimester until the GDM screen and risk of GDM. There also remained no association between adherence to rate of GWG from end of the first trimester until the GDM screen and risk of AGT or GDM. Among nulliparous women, each additional pound of GWG until the GDM screen became associated with a 2% lower risk of AGT (RR=0.98, 95% CI 0.96-0.999) after adjusting for age and pre-pregnancy BMI. There remained no association between GWG until the GDM screen and risk of GDM, and no association between adherence to IOM guidelines for total GWG until the GDM and risk of AGT or GDM. GWG in the first trimester, total GWG and adherence to IOM guidelines for total GWG remained unassociated with AGT nor GDM.

Lastly, we stratified our final models by pre-pregnancy BMI (Table 3.9). In general, the significant association between increasing GWG and decreased risk of AGT/GDM was limited to women who had a normal BMI prior to pregnancy. Specifically, among women with normal BMI before pregnancy and after adjusting for age, each additional pound of GWG until the GDM screen remained associated with a lower risk of AGT (RR=0.97, 95% CI 0.95-0.995). Each additional pound of total GWG

remained associated with a lower risk of AGT (RR=0.97, 95% CI 0.95-0.99), after adjusting for age. Excessive total GWG remained associated with a lower risk of AGT (RR=0.45, 95% CI 0.23-0.87).

In contrast, among women with who were overweight/obese prior to pregnancy, total GWG, excessive GWG until the GDM screen, and excessive total GWG were no longer significantly associated with AGT. However, rate of GWG from the end of the first trimester until GDM screen remained associated with a lower risk of AGT (RR=0.71, 95% CI 0.51-0.98) among overweight/obese women. None of the GWG variables were significantly associated with GDM among women who were overweight/obese prior to pregnancy.

Discussion

In summary, in this prospective cohort study among Hispanic prenatal care patients, we found, no association between GWG in the first trimester, GWG until GDM screen, and adherence to IOM guidelines for rate of GWG from end of first trimester until GDM screen, and risk of AGT, after adjusting for age and pre-pregnancy BMI. None of the GWG variables were associated with risk of GDM, after adjusting age and pre-pregnancy BMI. While we found that a higher rate of GWG from the end of the first trimester until the GDM screen, GWG until the GDM screen and total GWG were associated with lower risk of AGT, these associations were primarily limited to women who had a normal BMI before pregnancy.

Our findings of no association between GWG in the first trimester, GWG until GDM screen, and adherence to IOM guidelines for rate of GWG from end of first trimester until GDM screen, and risk of AGT, and no association between any of the

GWG variables and risk of GDM are consistent with 8 prior papers (76,88,158–163). Among these studies observing no association, 3 were prospective (88,159,163) and only 1 included Hispanic women (161). Our results were inconsistent with results of the only prior study to include a sample of entirely Hispanic women. Results from that study found no association between GWG until GDM screen and AGT among women with a normal BMI before pregnancy, and that women with a BMI ≥ 35 prior to pregnancy and excessive GWG until the GDM screen had an increased risk of impaired glucose tolerance, but not AGT (129).

Our unexpected finding that higher GWG was associated with lower risk of AGT and GDM is consistent, however, with some prior research on GWG and the risk of GDM (76,88,158–163). For example, a prospective cohort study by Li and colleagues (163) included 33,973 women (0% Hispanic). The authors stratified by pre-pregnancy BMI and categorized total GWG according to adherence to the 2009 IOM guidelines, and adjusted for age, height, education, smoking, income, occupation and weeks gestation at diagnosis. The authors found that excessive total GWG was associated with a 65% lower risk of GDM among women who were underweight before pregnancy (RR=0.35 95% CI 0.22-0.56) and a 28% lower risk of GDM among women who were normal weight before pregnancy (RR=0.72, 95% CI 0.63-0.84), compared to normal weight women with adequate GWG. They found no association between total GWG and risk of GDM among women who were overweight or obese before pregnancy. Similarly, we found that the association between excessive GWG and decreased risk of AGT/GDM was primarily limited to normal weight women. Among these women, excessive total GWG was

associated with a 55% lower risk of AGT, but not significantly associated with a lower risk of GDM.

Differences in our findings as compared to prior studies may have occurred due to the different populations under study. As previously discussed, excess energy consumption associated with increased GWG contributes to abnormally high iron levels that alter glucose metabolism (143–145). However, some research has indicated that the association between increased iron levels and higher risk of GDM may be limited to those with sufficient iron stores (171). Research indicates that Hispanic women of Caribbean descent have poorer iron status, compared to non-Hispanic white women (172). Therefore, if the women in this study had deficient iron stores before pregnancy, the excess energy and nutrients associated with excessive GWG may raise their iron stores to normal levels, which would be associated with a lower risk of GDM.

Our study had several strengths. We examined the association between GWG and risk of AGT / GDM among pregnant Hispanic women, a population underrepresented in prior literature examining this association, but who are at particularly high risk of both extreme weight gain and glucose abnormalities during pregnancy. Our study was prospective in nature, allowing us to assess temporality in the association between GWG and AGT / GDM. We were able to define GWG in several ways, expanding upon the definition of GWG, including biologically relevant weight gain time period (i.e., GWG in the first trimester), and allowing for measures of GWG that do not include weight gained after diagnosis of GDM (i.e., rate of GWG from the end of the first trimester until GDM screen and GWG until GDM screen). We were able to examine GWG both continuously and in categories according to adherence to IOM guidelines. Therefore, we were able to

gain a unique understanding of when during pregnancy women gain was most influential in regards to AGT and GDM.

However, our study also had several limitations. Firstly, a nondifferential misclassification of the exposure is possible. GWG is ascertained through abstraction of medical records. Self-reported pre-pregnancy weight is recorded by health professionals at the first prenatal visit. As previously discussed, self-reported pre-pregnancy weight has been found to differ from measured pre-pregnancy weight, and this may result in some nondifferential misclassification of both total GWG and adherence to IOM guidelines if pre-pregnancy BMI is misclassified. Women both under- and over-report pre-pregnancy weight. In addition, weight is measured at every prenatal visit and upon admission to the hospital during labor, although for clinical and not research purposes. Misclassification could occur due to scale calibration issues, women wearing clothing and shoes of various weights. The misclassification in pre-pregnancy weight may lead to misclassification in pre-pregnancy BMI and GWG calculations. It is likely, therefore, that the exposure was misclassified and the results of the study were biased toward the null. We expect the impact of this was modest, however, because prior studies have found that self-reported pre-pregnancy weight is highly correlated with measured pre-pregnancy weight. Misclassification of the outcomes, AGT and GDM, is possible if there were errors in glucose tolerance testing. This is unlikely, however, as the screening tests were clinically ordered and carried out using standard protocol with appropriate quality control measures, and abstracted from medical records. Further, the study physician confirmed suspected cases of GDM. Therefore, it is unlikely that AGT or GDM were misclassified.

There are two opportunities for bias in this study. Selection bias could have occurred if there was differential loss to follow-up. However, differential loss to follow-up is unlikely due to the ascertainment of outcome through abstraction of medical records, and would have been minimal, as eligibility criteria were limited to those planning to deliver at the study hospital. Further, in many cases, the medical records of participants delivering at another hospital were requested and obtained. Surveillance bias is possible if women with excessive GWG were more followed more closely by their provider for AGT or GDM than women without excessive GWG. To the extent that this occurred, it would cause an overestimate of the relative risk. However, Baystate Medical Center practices universal glucose screening, regardless of GWG. Therefore surveillance bias is unlikely to have occurred.

We tested a number of variables as confounders that have been identified in previous studies and important confounders were included in final multivariate models. Age and pre-pregnancy BMI were included in final models. Residual confounding was possible if the confounders were inaccurately measured. There was also the possibility for residual confounding by unmeasured confounders. For example, data was not collected on interval between pregnancies (for multiparous women). Short inter-pregnancy intervals (in particular, a year or less) may be positively associated with both increased GWG (173) and increased risk of GDM (due to weight retention from previous pregnancy) (173,174). Therefore, our inability to control for interval between pregnancies could have led to an overestimate of the relative risk between excessive GWG and GDM. To address this concern, we repeated our analysis among nulliparous women only and found the same pattern of results as among the full sample.

The results of this study may be generalized to pregnant women from the Caribbean Islands. Our results may not be generalized to pregnant women who have multiple births, as our study was restricted to mothers with singleton births. Multiple births increase GWG and may increase risk of AGT or GDM. The biological mechanism linking GWG to AGT and GDM is unlikely to vary by racial/ethnic group, but sociocultural practices and healthcare utilization may vary by racial/ethnic group, and therefore our findings may not be generalizable to non-Hispanic populations or other Hispanic subgroups.

In summary, we found that GWG in the first trimester, GWG until GDM screen, total GWG, and adherence to IOM guidelines for rate of GWG from end of first trimester until GDM screen were not associated with risk of AGT or GDM. While we found that increasing rate of GWG from the end of the first trimester until the GDM screen, excessive GWG until the GDM screen and excessive total GWG were associated with lower risk of AGT, these associations were primarily limited to women who had a normal BMI before pregnancy. Future studies are needed to further elucidate this association.

Table 3.1. Classification of Study Variables: Proyecto Buena Salud, 2006-2010.

Name	Description	Type
Outcome Variables		
agt	Abnormal Glucose Tolerance 0=no 1=yes	Dichotomous
gdm_ob_new	Gestational Diabetes Mellitus 0=no 1=yes	Dichotomous
Exposure Variables		
gwg_1st	GWG during 1st trimester	Continuous
rate_gdmscn	Rate of GWG from end of 1st trimester until GDM screen	Continuous
iom_rate_gdmscn	Adherence to IOM guidelines for rate of GWG, 1st tri - GDM screen 0=within recommendations 1=inadequate 2=excessive	Categorical
gwg_gdmscn	GWG until GDM screen	Continuous
iom_gwg_gdmscn	Adherence to IOM guidelines for GWG until GDM screen 0=within recommendations 1=inadequate 2=excessive	Categorical
total_gwg	Total GWG	Continuous
iom_total_gwg	Adherence to IOM guidelines for total GWG 0=within recommendations 1=inadequate 2=excessive	Categorical
Covariates		
age	Age 1=16-19 2=20-24 3=25-29 4=≥30	Categorical
married	Marital Status 1=Single/Separated/Divorced/Widowed 2=Married 3=Refused	Categorical
ed	Education 1=Less than high school 2=High school graduate or GED 3=Post high school	Categorical
income	Income 1=≤$15,000 2=>$15,000-$30,000 3=>$30,000 4=don't know/refuse	Categorical

Table 3.1., continued.

Name	Description	Type
adults	Number of Adults in Household 0=1 1=1 2=2 3=≥3	Categorical
kids	Number of Children in Household 0=1 1=1 2=2 3=≥3	Categorical
acc_status	Acculturation 1=low (1-<3) 2=high (≥3)	Dichotomous
generation	Generation in US 1=Born in PR/DR 2=Parent born in PR/DR 3=Grandparent born in PR/DR	Categorical
pregsmoke	Smoking During Early Pregnancy 0=None 1=<=10 cigs/day 2=Over 10 cigs/day	Categorical
pregalc	Alcohol Consumption During Early Pregnancy 0=no 1=yes	Dichotomous
eds_2	Probable Major Depression, Early Pregnancy	Continuous
ta	Trait Anxiety, Early Pregnancy (range: 20-80)	Continuous
sa	Stress, Early Pregnancy (range: 0-56)	Continuous
pregmettot1	Total Physical Activity, early pregnancy (MET hrs/week)	Continuous
pregmettot2	Total Physical Activity, mid pregnancy (MET hrs/week)	Continuous
totalcal	Total Energy Intake (calories)	Continuous
c_msick	Morning Sickness in Early Pregnancy 0=no 1=yes	Dichotomous
bmi_new	Pre-Pregnancy BMI 1= <18.5 2= 18.5-<25 3= 25-<30 4= ≥30	Categorical
gravidity_cat	Gravidity 0=0 previous pregnancies 1=1 previous pregnancy 2=2 or more previous pregnancies	Categorical

Table 3.1., continued.

Name	Description	Type
parity_cat	Parity 0=0 live births 1=1 live birth 2=2+ live births	Categorical
obh_gdm	History of GDM 0=no 1=yes	Dichotomous
obh_macrosom	History of Macrosomic Infant 0=no 1=yes	Dichotomous

Table 3.2. Number and Percent in Final Sample: Proyecto Buena Salud, 2006-2010.

Original Study Sample	1583	
Excluded		
Missing information on pre-pregnancy weight	37	2.3%
Spontaneous or therapeutic abortion before screening	65	4.1%
Missing glucose screening	204	12.9%
Missing glucose and delivery information		86
Missing glucose but have delivery information		118
Final Sample Size	1277	80.7%

Table 3.3. Distribution of GWG Variables: Proyecto Buena Salud, 2006-2010.

	N	M (SD) or %
Gestational Weight Gain During 1st Trimester (lbs)	1277	4.8 (8.3)
Rate of Weight Gain, end of 1st trimester to GDM screening (lbs/week)	1227	1.0 (0.6)
Adherence to IOM Guidelines for Rate of Weight Gain, 1st tri - screening	1215	
Inadequate Gestational Weight Gain	312	25.7%
Within Guidelines	184	15.1%
Excessive Gestational Weight Gain	719	59.2%
Gestational Weight Gained, until time of GDM screen (lbs)	1276	19.2 (13.4)
Adherence to IOM Guidelines for Gestational Weight Gain until Screen	1264	
Inadequate Gestational Weight Gain	284	22.5%
Within Guidelines	227	18.0%
Excessive Gestational Weight Gain	753	59.6%
Gestational Weight Gained, total (lbs)	1225	30.7 (16.0)
Adherence to IOM Guidelines for Gestational Weight Gain (total)	1201	
Inadequate Gestational Weight Gain	245	20.4%
Within Guidelines	343	28.6%
Excessive Gestational Weight Gain	613	51.0%

Table 3.4. Distribution of AGT / GDM: Proyecto Buena Salud, 2006-2010.

Abnormal Glucose Tolerance	1277		
No		1095	85.7%
Yes		182	14.3%
Gestational Diabetes Mellitus	1277		
No		1220	95.5%
AGT - no		1095	
AGT - yes		125	
Yes		57	4.5%

Table 3.5a. Distribution of Covariates According to GWG in 1st Trimester: Proyecto Buena Salud, 2006-2010.

	GWG, 1st Tri (continuous)		
	M	SD	p-value
Demographics			
Age			**p<0.001**
16-19	3.68	(7.50)	
20-24	4.74	(8.92)	
25-29	5.80	(8.04)	
≥30	6.49	(8.12)	
Marital Status			p=0.093
Single/Separated/Divorced/Widowed	4.60	(8.55)	
Married	6.04	(7.60)	
Refused	6.90	(6.61)	
Education			**p=0.039**
less than high school	4.40	(8.46)	
high school graduate or GED	4.68	(8.41)	
post high school	6.07	(8.23)	
Income			**p=0.020**
≤$15,000	4.16	(8.69)	
>$15,000-$30,000	5.57	(8.14)	
≥$30,000	7.17	(8.54)	
don't know/refuse	4.62	(8.32)	
Number of Adults in Household			p=0.487
1	5.23	(8.19)	
2	4.82	(8.40)	
≥3	4.40	(8.75)	
Number of Children in Household			p=0.633
0	5.44	(8.54)	
1	4.52	(8.14)	
2	4.94	(8.64)	
≥3	4.85	(8.73)	
Acculturation			p=0.452
low (1-<3)	4.84	(8.39)	
high (≥3)	4.36	(8.72)	
Generation in US			p=0.255
born in PR/DR	4.60	(8.21)	
parent born in PR/DR	4.93	(8.32)	
grandparent born in PR/DR	6.31	(8.34)	
Behavioral Characteristics			
Smoking During Early Pregnancy			p=0.626
None	4.60	(8.16)	
≤10 cigs/day	5.31	(8.65)	
>10 cigs/day	6.19	(13.64)	

Table 3.5a., continued.

	GWG, 1st Tri (continuous)		
	M	SD	p-value
Alcohol Consumption During Early Pregnancy			p=0.208
no	4.61	(8.20)	
yes	6.89	(8.07)	
Probable Major Depression, Early Pregnancy			p=0.085
no	4.87	(8.00)	
yes	3.55	(9.16)	
Trait Anxiety, Early Pregnancy (range: 20-80)			**p=0.028**
Mean (SD)	39.7	(10.2)	
Stress, Early Pregnancy (range: 0-56)			p=0.103
Mean (SD)	25.9	(7.0)	
Physical Activity, early pregnancy (METS/wk)			p=0.367
	187.9	(136.0)	
Physical Activity, mid pregnancy (METS/wk)			p=0.783
	184.3	(126.7)	
Total Energy Intake (calories)			p=0.089
	2096.7	(697.0)	
Characteristics of Pregnancy			
Morning Sickness in Early Pregnancy			**p=0.003**
no	5.87	(8.44)	
yes	4.30	(8.39)	
Medical History			
Pre-Pregnancy BMI			**p<0.001**
<18.5	7.38	(7.32)	
18.5-<25	5.64	(7.76)	
25-<30	5.21	(8.67)	
≥30	2.05	(8.45)	
Gravidity			**p=0.042**
1 total pregnancy	4.34	(7.90)	
2 total pregnancies	4.35	(8.09)	
3 or more total pregnancies	5.52	(8.41)	
Parity			**p=0.012**
0 live births	4.41	(7.80)	
1 live birth	4.37	(8.14)	
≥2 live births	5.93	(8.71)	
History of GDM			p=0.854
no	4.72	(8.23)	
yes	4.26	(6.70)	
History of Macrosomic Infant			**p=0.009**
no	4.67	(8.11)	
yes	10.92	(15.06)	

Table 3.5b. Distribution of Covariates According to Rate GWG (1st Trimester until GDM Screen): Proyecto Buena Salud, 2006-2010.

	Rate GWG 1st Tri - Screening			
	Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	%	%	%	p-value
Demographics				
Age				p=0.888
16-19	31.09%	34.97%	32.45%	
20-24	40.71%	39.89%	38.02%	
25-29	16.35%	15.85%	17.27%	
≥30	11.86%	9.29%	12.26%	
Marital Status				p=0.615
Single/Separated/Divorced/Widowed	88.15%	83.93%	88.09%	
Married	9.76%	13.10%	10.03%	
Refused	2.09%	2.98%	1.88%	
Education				p=0.048
less than high school	52.96%	50.00%	43.50%	
high school graduate or GED	28.57%	34.71%	35.29%	
post high school	18.47%	15.29%	21.21%	
Income				**p=0.031**
≤$15,000	34.97%	23.81%	28.53%	
>$15,000-$30,000	12.59%	18.45%	15.52%	
≥$30,000	3.85%	5.95%	8.31%	
don't know/refuse	48.60%	51.79%	47.65%	
Number of Adults in Household				p=0.885
1	25.52%	24.40%	26.88%	
2	48.95%	48.81%	45.78%	
≥3	25.52%	26.79%	27.34%	
Number of Children in Household				p=0.128
0	18.09%	18.67%	21.28%	
1	32.62%	43.98%	37.28%	
2	26.95%	21.69%	24.64%	
≥3	22.34%	15.66%	16.80%	
Acculturation				p=0.797
low (1-<3)	80.81%	79.50%	78.83%	
high (≥3)	19.19%	20.50%	21.17%	
Generation in US				p=0.053
born in PR/DR	50.00%	52.51%	43.49%	
parent born in PR/DR	46.00%	405.03%	50.36%	
grandparent born in PR/DR	4.00%	7.26%	6.15%	
Behavioral Characteristics				
Smoking During Early Pregnancy				p=0.195
None	83.81%	85.12%	88.46%	
≤10 cigs/day	14.29%	14.88%	10.90%	
>10 cigs/day	1.90%	0.00%	0.64%	
Alcohol Consumption During Early Pregnancy				p=0.053
no	99.52%	97.52%	96.57%	
yes	0.48%	2.48%	3.43%	

Table 3.5b., continued

	Rate GWG 1st Tri - Screening			
	Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	%	%	%	p-value
Probable Major Depression, Early Pregnancy				p=0.846
no	82.67%	84.75%	82.53%	
yes	17.33%	15.25%	17.47%	
Trait Anxiety, Early Pregnancy (range: 20-80)				p=0.843
Mean (SD)	39.9 (9.4)	39.6 (9.8)	39.4 (10.4)	
Stress, Early Pregnancy (range: 0-56)				p=0.511
Mean (SD)	25.7 (7.0)	26.5 (7.3)	25.7 (6.9)	
Physical Activity, early pregnancy (METS/wk)				p=0.702
	190.54 (144.68)	195.84 (136.12)	184.63 (133.57)	
Physical Activity, mid pregnancy (METS/wk)				p=0.202
	175.69 (121.26)	200.69 (158.75)	178.81 (112.60)	
Total Energy Intake (calories)				p=0.796
	2094.2 (740.9)	2154.5 (729.9)	2091.9 (670.8)	
Characteristics of Pregnancy				
Morning Sickness in Early Pregnancy				**p=0.028**
no	25.95%	31.61%	34.77%	
yes	74.05%	68.39%	65.23%	
Medical History				
Pre-Pregnancy BMI				**p<0.001**
<18.5	11.54%	11.41%	2.50%	
18.5-<25	43.59%	59.78%	45.48%	
25-<30	13.46%	16.85%	28.79%	
≥30	31.41%	11.96%	23.23%	
Gravidity				p=0.947
1 total pregnancy	31.72%	34.43%	34.31%	
2 total pregnancies	25.57%	25.14%	24.79%	
3 or more total pregnancies	42.72%	40.44%	40.90%	
Parity				p=0.523
0 live births	41.29%	41.53%	43.92%	
1 live birth	28.39%	32.79%	30.63%	
≥2 live births	30.32%	25.68%	25.45%	
History of GDM				p=0.131
no	98.97%	98.30%	99.57%	
yes	1.03%	1.70%	0.43%	
History of Macrosomic Infant				p=0.476
no	98.97%	100.00%	98.85%	
yes	1.03%	0.00%	1.15%	

Table 3.5c. Distribution of Covariates According to GWG until GDM Screen: Proyecto Buena Salud, 2006-2010.

	GWG until Screening			
	Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	%	%	%	p-value
Demographics				
Age				p=0.060
16-19	34.86%	35.68%	29.16%	
20-24	41.20%	34.36%	40.75%	
25-29	15.85%	14.98%	17.98%	
≥30	8.10%	14.98%	12.12%	
Marital Status				p=0.412
Single/Separated/Divorced/Widowed	89.18%	89.23%	85.91%	
Married	9.70%	8.21%	11.72%	
Refused	1.12%	2.56%	2.37%	
Education				**p=0.015**
less than high school	55.22%	47.72%	44.57%	
high school graduate or GED	30.60%	35.53%	33.43%	
post high school	14.18%	16.75%	21.99%	
Income				p=0.191
≤$15,000	30.97%	32.64%	28.93%	
>$15,000-$30,000	11.94%	16.06%	16.17%	
≥$30,000	4.48%	5.70%	8.01%	
don't know/refuse	52.61%	45.60%	46.88%	
Number of Adults in Household				p=0.984
1	25.75%	26.94%	25.70%	
2	46.64%	47.15%	48.15%	
≥3	27.61%	25.91%	26.14%	
Number of Children in Household				p=0.555
0	18.18%	15.43%	21.20%	
1	37.12%	37.77%	36.54%	
2	26.52%	24.47%	24.51%	
≥3	18.18%	22.34%	17.74%	
Acculturation				p=0.397
low (1-<3)	82.56%	79.03%	78.57%	
high (≥3)	17.44%	20.97%	21.43%	
Generation in US				**p=0.030**
born in PR/DR	51.66%	53.15%	43.31%	
parent born in PR/DR	44.28%	42.34%	50.27%	
grandparent born in PR/DR	4.06%	4.50%	6.42%	
Behavioral Characteristics				
Smoking During Early Pregnancy				p=0.472
None	83.74%	85.82%	87.42%	
≤10 cigs/day	14.78%	14.18%	11.55%	
>10 cigs/day	1.48%	0.00%	1.03%	
Alcohol Consumption During Early Pregnancy				p=0.371
no	98.51%	98.56%	96.71%	
yes	1.49%	1.44%	3.29%	

Table 3.5c., continued.

	GWG until Screening			
	Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	%	%	%	p-value
Probable Major Depression, Early Pregnancy				p=0.406
no	80.40%	81.02%	84.26%	
yes	19.60%	18.98%	15.74%	
Trait Anxiety, Early Pregnancy (range: 20-80)				p=0.206
Mean (SD)	40.3 (9.3)	40.7 (10.5)	39.2 (10.4)	
Stress, Early Pregnancy (range: 0-56)				p=0.487
Mean (SD)	25.9 (6.8)	26.5 (7.2)	25.7 (7.1)	
Physical Activity, early pregnancy (METS/wk)				p=0.723
	191.5 (158.0)	179.6 (111.2)	188.9 (132.9)	
Physical Activity, mid pregnancy (METS/wk)				p=0.972
	186.1 (148.8)	183.6 (134.2)	183.4 (114.4)	
Total Energy Intake (calories)				p=0.257
	2015.4 (673.8)	2090.5 (813.6)	2137.5 (675.2)	
Characteristics of Pregnancy				
Morning Sickness in Early Pregnancy				**p=0.028**
no	26.39%	29.50%	34.93%	
yes	73.61%	70.50%	65.07%	
Medical History				
Pre-Pregnancy BMI				**p<0.001**
<18.5	8.10%	9.69%	4.12%	
18.5-<25	39.08%	52.86%	47.41%	
25-<30	16.55%	16.30%	27.62%	
≥30	36.27%	21.15%	20.85%	
Gravidity				p=0.968
1 total pregnancy	32.03%	34.96%	32.66%	
2 total pregnancies	25.62%	24.34%	25.17%	
3 or more total pregnancies	42.35%	40.71%	42.17%	
Parity				p=0.857
0 live births	42.55%	40.71%	42.11%	
1 live birth	32.27%	31.42%	29.68%	
≥2 live births	25.18%	27.88%	28.21%	
History of GDM				p=0.436
no	98.52%	99.09%	99.31%	
yes	1.48%	0.91%	0.69%	
History of Macrosomic Infant				p=0.507
no	99.63%	99.07%	98.76%	
yes	0.37%	0.93%	1.24%	

Table 3.5d. Distribution of Covariates According to Total GWG: Proyecto Buena Salud, 2006-2010.

	Total GWG			
	Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	%	%	%	p-value
Demographics				
Age				p=0.406
16-19	32.24%	29.24%	32.52%	
20-24	42.45%	40.64%	37.91%	
25-29	15.10%	19.88%	16.50%	
≥30	10.20%	10.23%	13.07%	
Marital Status				p=0.832
Single/Separated/Divorced/Widowed	86.78%	87.29%	87.21%	
Married	10.57%	11.37%	10.45%	
Refused	2.64%	1.34%	2.34%	
Education				**p=0.013**
less than high school	56.83%	47.35%	43.85%	
high school graduate or GED	29.52%	34.44%	34.40%	
post high school	13.66%	18.21%	21.75%	
Income				p=0.145
≤$15,000	32.00%	31.31%	28.37%	
>$15,000-$30,000	9.78%	16.84%	17.41%	
≥$30,000	5.78%	7.41%	6.46%	
don't know/refuse	52.44%	44.44%	47.76%	
Number of Adults in Household				p=0.592
1	23.79%	25.93%	26.88%	
2	49.34%	50.84%	46.06%	
≥3	26.87%	23.23%	27.06%	
Number of Children in Household				p=0.070
0	15.25%	16.38%	21.76%	
1	40.81%	34.13%	38.21%	
2	26.01%	26.62%	23.58%	
≥3	17.94%	22.87%	16.45%	
Acculturation				p=0.485
low (1-<3)	82.51%	78.29%	79.47%	
high (≥3)	17.49%	21.71%	20.53%	
Generation in US				**p=0.015**
born in PR/DR	52.34%	51.35%	42.86%	
parent born in PR/DR	44.26%	43.84%	49.75%	
grandparent born in PR/DR	3.40%	4.80%	7.39%	
Behavioral Characteristics				
Smoking During Early Pregnancy				p=0.568
None	86.13%	83.41%	87.99%	
≤10 cigs/day	12.72%	15.64%	11.03%	
>10 cigs/day	1.16%	0.95%	0.98%	
Alcohol Consumption During Early Pregnancy				**p=0.024**
no	100.00%	97.17%	96.56%	
yes	0.00%	2.83%	3.44%	

Table 3.5d., continued.

	Total GWG			
	Inadequate GWG	Within IOM Guidelines	Excessive GWG	
	%	%	%	p-value
Probable Major Depression, Early Pregnancy				p=0.187
no	80.47%	79.90%	85.14%	
yes	19.53%	20.10%	14.86%	
Trait Anxiety, Early Pregnancy (range: 20-80)				p=0.056
Mean (SD)	40.8 (9.7)	40.4 (10.5)	38.9 (10.2)	
Stress, Early Pregnancy (range: 0-56)				p=0.204
Mean (SD)	26.6 (6.9)	26.2 (7.1)	25.5 (7.1)	
Physical Activity, early pregnancy (METS/wk)				p=0.534
	180.0 (156.6)	183.9 (119.1)	193.0 (136.3)	
Physical Activity, mid pregnancy (METS/wk)				p=0.906
	188.8 (152.7)	185.3 (125.3)	183.1 (116.9)	
Total Energy Intake (calories)				p=0.506
	2014.2 (684.8)	2100.3 (736.7)	2106.2 (690.8)	
Characteristics of Pregnancy				
Morning Sickness in Early Pregnancy				p=0.074
no	25.55%	33.98%	33.10%	
yes	74.45%	66.02%	66.90%	
Medical History				
Pre-Pregnancy BMI				**p<0.001**
<18.5	10.20%	7.87%	0.00%	
18.5-<25	50.61%	53.64%	42.74%	
25-<30	12.24%	18.66%	30.51%	
≥30	26.94%	19.83%	26.75%	
Gravidity				p=0.285
1 total pregnancy	31.56%	30.32%	35.30%	
2 total pregnancies	26.64%	23.62%	25.62%	
3 or more total pregnancies	41.80%	46.06%	39.08%	
Parity				p=0.090
0 live births	37.14%	39.94%	44.92%	
1 live birth	36.33%	29.45%	29.67%	
≥2 live births	26.53%	30.61%	25.41%	
History of GDM				p=0.588
no	98.73%	99.10%	99.32%	
yes	1.27%	0.90%	0.68%	
History of Macrosomic Infant				p=0.308
no	99.15%	99.70%	98.64%	
yes	0.85%	0.30%	1.36%	

Table 3.6. Distribution of Covariates According to AGT / GDM: Proyecto Buena Salud, 2006-2010.

	Abnormal Glucose Tolerance			Gestational Diabetes Mellitus		
	No	Yes		No	Yes	
	%	%	p-value	%	%	p-value
Demographics						
Age			**p<0.001**			**p<0.001**
16-19	33.58%	19.23%		33.58%	14.04%	
20-24	40.90%	31.87%		40.90%	17.54%	
25-29	15.83%	23.63%		15.83%	29.82%	
≥30	9.70%	25.27%		9.70%	38.60%	
Marital Status			**p=0.037**			**p=0.043**
Single/Separated/Divorced/Widowed	88.22%	80.98%		88.22%	76.92%	
Married	9.85%	15.95%		9.85%	19.23%	
Refused	1.93%	3.07%		1.93%	3.85%	
Education			**p=0.036**			**p=0.039**
less than high school	48.89%	40.24%		48.89%	30.77%	
high school graduate or GED	32.70%	33.54%		32.70%	44.23%	
post high school	18.41%	26.22%		18.41%	25.00%	
Income			p=0.477			**p=0.009**
≤$15,000	29.81%	31.90%		29.81%	40.38%	
>$15,000-$30,000	14.55%	18.40%		14.55%	26.92%	
≥$30,000	7.02%	6.13%		7.02%	3.85%	
don't know/refuse	48.63%	43.56%		48.63%	28.85%	
Number of Adults in Household			p=0.365			p=0.676
1	26.37%	22.70%		26.37%	21.15%	
2	46.86%	52.76%		46.86%	51.92%	
≥3	26.77%	24.54%		26.77%	26.92%	
Number of Children in Household			p=0.530			p=0.903
0	19.81%	17.61%		19.81%	15.69%	
1	36.53%	38.36%		36.53%	39.22%	
2	25.49%	22.01%		25.49%	25.49%	
≥3	18.16%	22.01%		18.16%	19.61%	
Acculturation			p=0.101			p=0.516
low (1-<3)	78.79%	84.52%		78.79%	75.00%	
high (≥3)	21.21%	15.48%		21.21%	25.00%	
Generation in US			**p=0.008**			**p=0.005**
born in PR/DR	45.38%	56.57%		45.38%	67.92%	
parent born in PR/DR	48.40%	41.14%		48.40%	30.19%	
grandparent born in PR/DR	6.23%	2.29%		6.23%	1.89%	
Behavioral Characteristics						
Smoking During Early Pregnancy			p=0.172			p=0.723
None	86.38%	86.07%		86.38%	85.00%	
≤10 cigs/day	12.92%	11.48%		12.92%	15.00%	
>10 cigs/day	0.70%	2.46%		0.70%	0.00%	
Alcohol Consumption During Early Pregnancy			p=0.755			p=0.617
no	97.33%	98.32%		97.33%	100.00%	
yes	2.67%	1.68%		2.67%	0.00%	

Table 3.6., continued.

	Abnormal Glucose Tolerance			Gestational Diabetes Mellitus		
	No	Yes		No	Yes	
	%	%	p-value	%	%	p-value
Probable Major Depression, Early Pregnancy			p=0.634			p=0.496
no	83.00%	81.20%		83.00%	87.18%	
yes	17.00%	18.80%		17.00%	12.82%	
Trait Anxiety, Early Pregnancy (range: 20-80)			p=0.289			p=0.543
Mean (SD)	39.9 (10.2)	38.9 (9.8)		39.9 (10.2)	38.9 (9.8)	
Stress, Early Pregnancy (range: 0-56)			p=0.267			p=0.323
Mean (SD)	26.0 (7.0)	25.2 (7.0)		26.0 (7.0)	24.9 (7.1)	
Physical Activity, early pregnancy (METS/wk)			p=0.155			p=0.719
Mean (SD)	190.7 (137.4)	171.1 (126.6)		190.7 (137.4)	199.1 (161.4)	
Physical Activity, mid pregnancy (METS/wk)			p=0.832			p=0.876
Mean (SD)	184.7 (127.5)	181.8 (122.5)		184.7 (127.5)	181.0 (109.6)	
Total Energy Intake (calories)			p=0.606			P=0.880
Mean (SD)	2089.9 (696.0)	2134.4 (705.6)		2089.9 (696.0)	2113.0 (780.0)	
Characteristics of Pregnancy						
Morning Sickness in Early Pregnancy			p=0.535			p=0.881
no	31.70%	34.15%		31.70%	32.69%	
yes	68.30%	65.85%		68.30%	67.31%	
Medical History						
Pre-Pregnancy BMI			**p<0.001**			**p<0.001**
<18.5	6.54%	2.79%		6.54%	0.00%	
18.5-<25	48.62%	33.52%		48.62%	24.56%	
25-<30	22.28%	27.93%		22.28%	31.58%	
≥30	22.56%	35.75%		22.56%	43.86%	
Gravidity			p=0.128			p=0.196
0 previous pregnancies	33.61%	29.21%		33.61%	22.81%	
1 previous pregnancy	25.60%	21.91%		25.60%	26.32%	
2 or more previous pregnancies	40.79%	48.88%		40.79%	50.88%	
Parity			**p=0.048**			**p=0.027**
0 live births	43.33%	34.08%		43.33%	26.32%	
1 live birth	30.08%	32.40%		30.08%	43.86%	
≥2 live births	26.59%	33.52%		26.59%	29.82%	
History of GDM			**p<0.001**			**p=0.003**
no	85.53%	95.95%		99.62%	94.44%	
yes	0.33%	4.05%		0.38%	5.56%	
History of Macrosomic Infant			p=0.396			p=0.403
no	99.14%	98.29%		99.14%	98.18%	
yes	0.86%	1.71%		0.86%	1.82%	

Table 3.7. Unadjusted and Adjusted Relative Risks and 95% Confidence Intervals for GWG Variables and AGT / GDM: Proyecto Buena Salud, 2006-2010.

	Abnormal Glucose Tolerance				Gestational Diabetes Mellitus			
	Unadjusted		Adjusted for age and pre-pregnancy BMI		Unadjusted		Adjusted for age and pre-pregnancy BMI	
	Crude RR	95% CI	RR	95% CI	Crude RR	95% CI	RR	95% CI
Gestational Weight Gain During 1st Trimester (lbs)	1.00	(0.98-1.01)	1.00	(0.98-1.02)	1.00	(0.97-1.04)	1.01	(0.98-1.05)
Rate of Gestational Weight Gain, end of 1st Trimester to GDM Screen (lbs/wk)	**0.58**	**(0.44-0.76)**	**0.68**	**(0.51-0.92)**	**0.63**	**(0.42-0.95)**	0.82	(0.50-1.37)
Adherence to IOM Guidelines for Rate of Weight Gain, 1st tri - screening								
Inadequate Gestational Weight Gain	1.36	(0.82-2.27)	1.14	(0.68-1.96)	0.96	(0.41-2.28)	0.82	(0.33-2.08)
Within Guidelines	1.00	Referent	1.00	Referent	1.0	Referent	1.0	Referent
Excessive Gestational Weight Gain	0.86	(0.54-1.39)	0.76	(0.46-1.25)	0.35	(0.35-1.63)	0.71	(0.31-1.61)
Gestational Weight Gained until GDM Screen (lbs)	**0.98**	**(0.97-0.99)**	0.99	(0.98-1.00)	0.98	(0.97-1.00)	1.00	(0.98-1.02)
Adherence to IOM Guidelines for Gestational Weight Gain until Screen								
Inadequate Gestational Weight Gain	1.03	(0.65-1.63)	1.01	(0.62-1.65)	0.74	(0.33-1.66)	0.73	(0.30-1.76)
Within Guidelines	1.00	Referent	1.0	Referent	1.00	Referent	1.0	Referent
Excessive Gestational Weight Gain	**0.65**	**(0.43-0.97)**	**0.65**	**(0.42-0.99)**	0.68	(0.35-1.32)	0.75	(0.37-1.54)
Total Gestational Weight Gain (lbs)	**0.98**	**(0.97-0.99)**	0.99	(0.98-1.00)	**0.97**	**(0.96-0.99)**	0.99	(0.97-1.01)
Adherence to IOM Guidelines for Gestational Weight Gain (total)								
Inadequate Gestational Weight Gain	1.07	(0.69-1.65)	1.00	(0.63-1.58)	1.25	(0.61-1.42)	1.07	(0.50-2.32)
Within Guidelines	1.00	Referent	1.0	Referent	1.00	Referent	1.0	Referent
Excessive Gestational Weight Gain	**0.68**	**(0.47-0.99)**	**0.62**	**(0.42-0.92)**	0.75	(0.40-1.42)	0.66	(0.34-1.28)

Table 3.8. Adjusted Relative Risks and 95% Confidence Intervals for GWG Variables and AGT / GDM, Restricted to Nulliparous Women: Proyecto Buena Salud, 2006-2010.

	Risk of AGT Nulliparous		Risk of GDM Nulliparous	
	Adjusted for age and pre-pregnancy BMI		Adjusted for age and pre-pregnancy BMI	
	RR	95% CI	RR	95% CI
Gestational Weight Gain During 1st Trimester (lbs)	0.98	(0.95-1.02)	1.05	(0.98-1.13)
Rate of Gestational Weight Gain, end of 1st Trimester to GDM Screen (lbs/wk)	**0.61**	**(0.38-0.96)**	0.96	(0.40-2.31)
Adherence to IOM Guidelines for Rate of Weight Gain, 1st tri - screening				
Inadequate Gestational Weight Gain	1.18	(0.52-2.72)	1.11	(0.19-6.48)
Within Guidelines	1.00	Referent	1.00	Referent
Excessive Gestational Weight Gain	0.55	(0.25-1.22)	0.76	(0.15-3.81)
Gestational Weight Gained until GDM Screen (lbs)	**0.98**	**(0.96-0.999)**	1.02	(0.98-1.07)
Adherence to IOM Guidelines for Gestational Weight Gain until Screen				
Inadequate Gestational Weight Gain	0.98	(0.45-2.12)	0.29	(0.03-2.59)
Within Guidelines	1.00	Referent	1.00	Referent
Excessive Gestational Weight Gain	0.55	(0.29-1.04)	0.77	(0.25-2.39)
Total Gestational Weight Gain (lbs)	0.98	(0.97-1.00)	1.00	(0.97-1.03)
Adherence to IOM Guidelines for Gestational Weight Gain (total)				
Inadequate Gestational Weight Gain	1.42	(0.64-3.16)	0.38	(0.03-4.45)
Within Guidelines	1.00	Referent	1.00	Referent
Excessive Gestational Weight Gain	0.66	(0.32-1.37)	1.56	(0.33-7.47)

Table 3.9. Adjusted Relative Risks and 95% Confidence Intervals for GWG Variables and AGT / GDM, Stratified by Pre-Pregnancy BMI: Proyecto Buena Salud, 2006-2010.

	Risk of AGT Underweight (n=88)		Risk of AGT Normal BMI (n=600)		Risk of AGT Overweight/Obese (n=613)		Risk of GDM Underweight (n=88)		Risk of GDM Normal BMI (n=600)		Risk of GDM Overweight/Obese (n=613)	
	Adjusted for age		Adjusted for age		Adjusted for age		Adjusted for age		Adjusted for age		Adjusted for age	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Gestational Weight Gain During 1st Trimester (lbs)	0.96	(0.86-1.08)	0.97	(0.94-1.00)	1.01	(0.98-1.03)	-	-	0.98	(0.91-1.05)	1.01	(0.97-1.05)
Rate of Gestational Weight Gain, end of 1st Trimester to GDM Scre	0.51	(0.09-2.73)	0.60	(0.34-1.08)	**0.71**	**(0.51-0.98)**	0.83	(0.55-1.25)	0.67	(0.21-2.10)	0.81	(0.47-1.38)
Adherence to IOM Guidelines for Rate of Weight Gain, 1st tri - screening												
Inadequate Gestational Weight Gain	2.08	(0.20-21.94)	0.9	(0.41-1.99)	1.54	(0.70-3.40)	-	-	0.79	(0.15-4.12)	0.88	(0.29-2.68)
Within Guidelines	1.0	Referent	1.0	Referent	1.0	Referent	-	-	1.0	Referent	1.0	Referent
Excessive Gestational Weight Gain	1.78	(0.09-36.35)	0.66	(0.33-1.34)	0.82	(0.39-1.74)	-	-	0.73	(0.15-2.90)	0.57	(0.20-1.58)
Gestational Weight Gained until GDM Screen (lbs)	0.96	(0.89-1.04)	**0.97**	**(0.95-0.995)**	0.99	(0.98-1.00)	-	-	0.98	(0.94-1.03)	0.99	(0.97-1.02)
Adherence to IOM Guidelines for Gestational Weight Gain until Screen												
Inadequate Gestational Weight Gain	1.03	(0.13-8.25)	0.87	(0.40-1.90)	1.31	(0.68-2.54)	-	-	0.24	(0.03-2.18)	1.14	(0.41-3.19)
Within Guidelines	1.0	Referent	1.0	Referent	1.0	Referent	-	-	1.0	Referent	1.0	Referent
Excessive Gestational Weight Gain	0.38	(0.03-4.59)	0.54	(0.28-1.02)	0.74	(0.41-1.35)	-	-	0.48	(0.15-1.54)	0.82	(0.33-2.03)
Total Gestational Weight Gain (lbs)	1.01	(0.93-1.09)	**0.97**	**(0.95-0.99)**	0.99	(0.97-1.00)	-	-	0.96	(0.92-1.00)	0.99	(0.997-1.01)
Adherence to IOM Guidelines for Gestational Weight Gain (total)												
Inadequate Gestational Weight Gain	-	-	1.15	(0.59-2.23)	1.22	(0.65-2.29)	-	-	1.2	(0.35-4.16)	1.31	(0.50-3.42)
Within Guidelines	-	-	1.0	Referent	1.0	Referent	-	-	1.0	Referent	1.0	Referent
Excessive Gestational Weight Gain	-	-	**0.45**	**(0.23-0.87)**	0.68	(0.41-1.13)	-	-	0.30	(0.07-1.23)	0.72	(0.33-1.60)

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